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WEDNESDAY, OCTOBER 18, 1978
PART II

ENVIRONMENTAL PROTECTION AGENCY

WOOD PRESERVATIVE PESTICIDES

Initiation of Schedule for Review

and

Notices of Rebuttable Presumption Against Registration of Certain Pesticides

[6560-01-M]

ENVIRONMENTAL PROTECTION AGENCY

[FRL 987-1; OPP-90077]

PESTICIDE PROGRAMS

Initiation of Schedule for Review of Wood Preservative Pesticides

The U.S. Environmental Protection Agency (EPA) has published today elsewhere in this part of the FEDERAL REGISTER, notices of rebuttable presumption against registration (RPAR) on inorganic arsenic, pentachlorophenol, and coal tar, creosote, and coal tar neutral oil. These chemicals comprise the most widely used industrial pesticide wood treatments available. Therefore, the wood treatment uses of these pesticides will be considered together in the risk-benefit part of the RPAR review process. In addition to providing data and information on each of the compounds RPAR'd, persons are invited to comment on the comparative risks and benefits of these three chemicals. This will assist the Agency in assessing tradeoffs. Other uses for these pesticides will be considered in individual risk/benefit analyses for each chemical. Please refer to the separate RPAR notices for information on submission of comments, rebuttals, and benefits data.

A tentative schedule has been established for completion of the RPAR review of the wood-treatment uses of inorganic arsenic, pentachlorophenol, coal tar and its derivatives:

Mid-January 1979—deadline for submission of rebuttals and comments (based on EPA's expectation that a 60-day extension to the comment period will be requested).

Second quarter, 1979—submission of benefits/exposure comments by USDA Benefit Assessment Team.

Third quarter, 1979—complete rebuttal review (if the rebuttals are successful for any of these chemicals, that chemical will be referred for registration or reregistration; if the rebuttals are not successful, EPA will continue its regulatory review).

First quarter, 1980—USDA/SAP review of EPA's proposed regulatory options.

Second quarter, 1980—Final regulatory decision on the wood-treatment uses of inorganic arsenic, pentachlorphenol, coal tar and its derivatives, as appropriate.

Dated: October 6, 1978.

EDWIN L. JOHNSON,
Deputy Assistant Administrator for Pesticide Programs.

[FR Doc.78-28933 Filed 10-17-78; 8:45 am]

[6560-01-M]

[FRL 984-4; OPP-30000/28]

PESTICIDE PROGRAMS

Notice of Rebuttable Presumption Against Registration and Continued Registration of Pesticide Products Containing Coal Tar, Creosote, and Coal Tar Neutral Oil

AGENCY: Office of Pesticide Programs, Environmental Protection Agency (EPA)

ACTION: Notice of rebuttable presumption.

SUMMARY: Coal tar, creosote, and coal tar neutral oil have been found to exceed certain risk criteria set forth in 40 CFR 162.11. This notice requests registrants and other interested persons to submit rebuttals and other information on the presumption and to submit any other data on the risks and benefits of these pesticide chemicals. This notice is the first of several which will give public notification of the Agency's progress in reviewing this chemical. Today EPA is also publishing in the FEDERAL REGISTER notices of rebuttable presumption against registration (RPAR) on pentachlorophenol (PCP) and inorganic arsenicals. Since coal tar, creosote, and coal tar neutral oil, PCP, and inorganic arsenic comprise the most widely used of pesticide wood treatments available, the wood treatment uses of these pesticides will be considered together in the risk/benefit part of the RPAR review process. Other uses for these pesticides will be considered in individual risk/benefit analysis for each chemical.

DATE: Rebuttal evidence and other information must be received on or before December 4, 1978.

ADDRESS MATERIAL TO: Federal Register Section, Program Support Division (TS-757), Office of Pesticide Programs, EPA, Room 401, East Tower, 401 M Street SW., Washington, D.C. 20460.

FOR FURTHER INFORMATION CONTACT:

Herman J. Gibb, Special Pesticide Review Division, Office of Pesticide Programs (TS-791), Office of Toxic Subtances, Room 447, East Tower, EPA, 202-755-5632.

SUPPLEMENTARY INFORMATION: The Deputy Assistant Administrator, Office of Pesticide programs, EPA, has determined that a rebuttable presumption exists against registration and continued registration of all pesticide products containing coal tar, creosote, and coal tar neutral oil.[1] Issuance of this RPAR means that potential adverse effects associated with the use of coal tar, creosote, and coal tar neutral oil have been identified and will be examined further to determine if they do exist and, if so, whether they are unreasonable. This process involves a public review of both the risks and the benefits associated with the use of these pesticide chemicals. The RPAR does not mean that the Agency has decided to cancel or suspend the registration of these chemicals or to take any other action with respect to them; EPA has not made a finding that use of any products containing these ingredients present an imminent hazard. Any pesticide subject to this RPAR may lawfully be sold, distributed, and used for all uses for which it is registered and labeled.

[1] A position document, containing an appendix of references, background information, and other material pertinent to the issuance of this notice, has been prepared by the Agency on coal tar and coal tar products and is also published with this notice.

I. REGULATORY PROVISIONS

A. *General.* Title 40, part 162.11 of the Code of Federal Regulations for the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended (86 Stat. 973, 89 Stat. 751, 7 U.S.C. 136 et seq.), provides that a rebuttable presumption against registration shall arise if the Agency determines that a pesticide meets or exceeds any of the risk criteria relating to acute and chronic toxic effects set forth in section 162.11(a)(3). If it is determined that such a rebuttable presumption has arisen, the regulations require that the registrant be notified by certified mail and afforded an opportunity to submit evidence in rebuttal of the presumption. In addition, the Agency has determined that the public should also be given notice of the bases for the presumption to provide an opportunity for comment and to solicit additional information relevant to the presumption.

A notice of rebuttable presumption against registration is issued when the evidence related to risk meets the criteria set forth in section 162.11(a)(3). It is emphasized that a notice of rebuttable presumption against registration and continued registration of a pesticide is not a notice of intent to cancel the registration of a pesticide, and may or may not lead to cancellation. The notice of intent to cancel is issued only after the risks and benefits of a pesticide are carefully considered, and it is determined that the pesticide may generally cause unreasonable adverse effects to the environment.

All registrants and applicants for registration are invited pursuant to 40 CFR 162.11(a)(4) to submit evidence in rebuttal of the presumptions listed in part II of this notice and, in the case of oncogenicity, to submit information which relates to the assessment of oncogenic risks as set forth in the Agency's Interim Procedures and Guidelines for Health Risk and Economic

Impact Assessment of Suspected Carcinogens (May 25, 1976; 41 FR 21402). Registrants and other interested parties may submit for consideration data on benefits which they believe would justify registration or continued registration. In addition, any registrant may petition the Agency to voluntarily cancel a current registration pursuant to section 6(a)(1) of FIFRA.

B. *Rebuttal criteria.* Section 162.11(a)(4) provides that a registrant may rebut the presumption by sustaining the burden of proving:

(1) In the case of a pesticide presumed against pursuant to the acute toxicity or lack of emergency treatment criteria, "that when considered with the formulation, packaging, method of use, and proposed restrictions on the directions for use and widespread and commonly recognized practices of use, the anticipated exposure to an applicator or user and to local, regional, or national populations of nontarget organisms is not likely to result in any significant acute adverse effects" (40 CFR 162.11(a)(4)(i));

(2) In the case of a pesticide presumed against pursuant to the chronic toxicity criteria, "that when considered with proposed restrictions on use and widespread and commonly recognized practices of use, the pesticide will not concentrate, persist or accrue to levels in man or the environment likely to result in any significant chronic adverse effects" (40 CFR 162.11(a)(4)(ii)); or

(3) In either case, that "the determination by the Agency that the pesticide meets or exceeds any of the criteria for risk was in error" (40 CFR 162.11(a)(4)(iii)).

C. *Benefits information.* In addition to submitting evidence to rebut the presumption of risk, section 162.11(a)(5)(iii) provides that a registrant "may submit evidence as to whether the economic, social, and environmental benefits of the use of the pesticide subject to the presumption outweigh the risk of use." If the risk presumptions are not rebutted the benefit evidence [2] submitted by the registrant, applicants, and other interested persons will be considered by the Administrator in determining the appropriate regulatory action. Specifically, section 162.11(a)(5)(iii) provides that if the benefits appear to outweigh the risks, the Administrator may issue a notice of intent to hold a hearing purusant to section 6(b)(2) of FIFRA to determine whether the registration(s) should be canceled or application(s) denied. Alternatively, if the "benefits do not appear to outweigh the risks, the Administrator shall issue a notice pursuant to section 3(c)(6) or section 6(b)(1) of the Act, as appropriate." Moreover, if at any time the Administrator determines that a pesticide poses an "imminent hazard" to humans or the environment, a notice of suspension may be issued pursuant to section 6(c) of the Act.

II. Presumptions

Registrations and applications for registration of pesticide products containing coal tar, creosote, and coal tar neutral oil meet or exceed the 40 CFR 162.11(a)(3) risk criteria relating to oncogenicity. Registrations and applications for registration of pesticide products containing creosote or coal tar-creosote mixtures meet or exceed the 40 CFR 162.11(a)(3) risk criteria relating to mutagenicity. The Agency's basis for concluding that these risk criteria have been met or exceeded is set out in "Coal Tar, Creosote, and Coal Tar Neutral Oil: Position Document 1," which follows. Copies of attachments to the Position Document which are not published with this notice are available for public inspection in the Special Pesticide Review Division. Information protected from disclosure pursuant to FIFRA Section 10 cannot be provided. Specific inquiries concerning the Position Document, as well as requests for access to these files, should be directed to Project Manager Herman J. Gibb, Special Pesticide Review Division (TS-791), EPA, Room 447, East Tower, 401 M Street SW., Washington, D.C. 20460, 202-755-5632.

A. *Oncogenicity.* 40 CFR Section 162.11(a)(3)(ii)(A) provides that a rebuttable presumption shall arise if a pesticide "(i)nduces oncogenic effects in experimental mammalian species or in man as a result of oral, inhalation, or dermal exposure * * *."

On the basis of scientific studies and information summarized in the Position Document, the Agency has concluded that all registrations and applications for registration of pesticide products containing coal tar, creosote, or coal tar neutral oil exceed this risk criterion, and that a rebuttable presumption against new or continued registration of such products has arisen.

B. *Mutagenicity.* 40 CFR Section 162.11(a)(3)(ii)(A) provides that a rebuttable presumption shall arise if a pesticide "* * * induces mutagenic effects, as determined by multitest evidence."

On the basis of scientific studies and information summarized in the Position Document, the Agency has concluded that all registrations and applications for registration of pesticide products containing creosote or coal tar-creosote mixtures exceed this risk criterion, and that a rebuttable presumption against new or continued registration of such products has arisen.

III. Additional Grounds for Review

As discussed in detail in the attached Position Document, some data has associated creosote with human skin and eye irritation, livestock fatality, and fetotoxicity in test animals. The data and analyses available at this time with respect to this effect are not sufficient to warrant the issuance of a rebuttable presumption. The Agency specifically solicits further evidence bearing on these possible adverse effects. All comments and information received with respect to the potential adverse effects, including analysis thereof, may serve as a basis for a final decision on registering pesticides containing creosote.

Rebuttal Submission Procedures

All registrants and applicants for registration listed below are being notified by certified mail of the rebuttable presumption existing against registration and continued registration of their products.

The registrants and applicants for registration shall have 45 days from the date this notice is sent or until December 4, 1978, to submit evidence in rebuttal of the presumption. However, the Administrator may, for good cause shown, grant an additional 60 days during which such evidence may be submitted. Notice of such an extension, if granted, will appear in the Federal Register.

A registrant or applicant for registration may, if it desires, assert a business confidentiality claim covering part or all of the information submitted in rebuttal. The registrant or applicant may assert the claim by placing on or attaching to the information a cover sheet, stamped or typed legend, or other suitable form of notice employing language such as

[2] Registrants or other interested persons who desire to submit benefits information should consider submitting information on the following subjects, along with any other relevant information they desire to submit:

1. Identification of the major uses of the pesticide, including estimated quantities used by crop or other application.
2. Identification of the minor uses of the pesticide, including estimated quantities used by category such as lawn and garden uses and household uses.
3. Identification of registered alternative products for the uses set forth in (1) and (2) above, including an estimate of their availability.
4. Determination of the change in costs to the user of providing equivalent pesticide treatment with any available substitute products.
5. Assessment of regulation impact upon user productivity (e.g., yield per acre and/or total output) from using available substitute pesticides or from using no other pesticides.
6. If the impacts upon either user costs or productivity are significant, a qualitative assessment of the regulation's impact on production of major agricultural commodities and retail food prices of such commodities.

"trade secret," "proprietary," or "company confidential." Allegedly confidential portions of otherwise nonconfidential documents should be clearly marked.

If a confidentiality claim is asserted, the information covered by the claim will be disclosed by EPA only to the extent and by means of the procedures set forth in 40 CFR Part 2, Subpart B (41 FR 36906; Sept. 1, 1976). If no confidentiality claim accompanies the information at the time it is received by EPA, EPA will place the information in the public comment file where it will be available for public inspection.

If a registrant or applicant does assert a confidentiality claim for some, but not all, of the information submitted to EPA in rebuttal, the registrant or applicant should furnish two copies of the information to EPA. The first copy should contain all of the information submitted in rebuttal with information claimed as confidential clearly identified. The second copy should be identical to the first except that all information claimed as confidential should be deleted. The second copy will be placed in the public comment file. The first copy will be treated in accordance with the procedures set out above.

V. Duty To Submit Information on Adverse Effects

Registrants are required by law to submit to EPA any additional information regarding any adverse effects on man or the environment which comes to a registrant's attention at any time, pursuant to section 6(a)(2) of FIFRA and 40 CFR 162.8(d). If any registrant of products containing coal tar, creosote, or coal tar neutral oil has any published or unpublished information, studies, reports, analyses, or reanalyses regarding any adverse effects in animal species or humans, residues, and claimed or verified accidents to humans, domestic animals, or wildlife, which have not been previously submitted to EPA, the material must be submitted immediately. When responding to this notice, each registrant shall submit a written certification to the Agency that all information regarding any adverse effects known to the registrant has been submitted. In addition, the registrants should notify EPA of any studies currently in progress, including the purpose of the study, the protocol, the approximate completion date, and a summary of all results observed to date.

VI. Public Comments and Inspection

During the time allowed for submission of rebuttual evidence, specific comments on the presumptions set forth in this notice and on the material contained in the Position Document are solicited from the public. In particular, any documented episodes of adverse effects to humans, domestic animals, or wildlife, and information as to any laboratory studies in progress or completed are requested to be submitted to EPA as soon as possible. Specifically, information on the fate and effects of coal tar, creosote, or coal tar neutral oil, its impurities metabolites, and degradation products on flora and fauna, particularly animals with metabolism similar to man, is solicited. Similarly, any studies or comments on the benefits from the use of coal tar, cresoste, or coal tar neutral oil are requested to be submitted. All comments and information received, as well as any other relevant information and analysis thereof, which come to the attention of the Agency may serve as a basis for final determination pursuant to section 162.11(a)(5).

All comments and information should be sent to the Office of Federal Register Section at the address given above, if possible in triplicate to facilitate the work of the Agency and others interested in inspecting them. The comments and information should bear the identifying notation "OPP-30000/28." Comments received after the specified time period will be considered only to the extent feasible, consistent with the time limits imposed by 40 CFR Section 162.11(a)(5)(ii).

All written comments and information filed pursuant to this notice will be available for public inspection in the Office of the Federal Register Section from 8:30 a.m. to 4 p.m., during normal working days. Interested persons are encouraged to take advantage of the opportunity to inspect Agency files during normal working hours since: (1) All of the information received may serve as a basis for final determination pursuant to section 162.11(a)(5), and (2) the Agency will not generally publish a summary of information received in the Federal Register at the close of the rebuttal period.

Your cooperation is solicited in identifying any errors or omissions which may have been made in the following computer listings. Corrections to the listings may not necessarily be published in the Federal Register, but rather handled by mail with affected parties. Ommissions will be corrected by notice in the Federal Register.

Dated: September 30, 1978.

Edwin L. Johnson,

Deputy Assistant Administrator for Pesticide Programs.

[6560-01-C]

COAL TAR, CREOSOTE, AND COAL TAR NEUTRAL OIL

POSITION DOCUMENT 1

Coal Tar and Coal Tar Products Working Group
Herman Gibb, Project Manager
U.S. Environmental Protection Agency

I. Background

A. Chemical and Physical Characteristics

Coal tar is produced by the carbonization, also called coking, of coal. Creosote and neutral oils are products of coal tar. Although creosote and neutral oil may be distilled from sources other than coal, the terms "creosote" and neutral oil" in this document will refer to distillates of coal tar. Coal tar is described in the Condensed Chemical Dictionary (Hawley, 1977) as:

> A black, viscous liquid (or semi-solid), naphthalene-like odor; sharp burning taste; obtained by the destructive distillation of bituminous coal, as in coke ovens; 1 ton of coal yields 8.8 gallons of coal tar. Combustible. Specific gravity 1.15-1.23 (60/60°F). Soluble in ether, benzene, carbon disulfide, chloroform; partially soluble in alcohol, acetone, methanol, and benzene; only slightly soluble in water.

Although it has other uses, the term creosote usually refers to that coal tar distillate which is used for wood preservation. Definitions of creosote vary, however.[1/]

1/ As a wood preservative, creosote is defined by the American Wood Preservers' Association (1976) as:

> A distillate derived from coal tar. As used in the wood preserving industry, creosote denotes a distillate of coal tar produced by the high temperature carbonization of bituminous coal. Creosote consists principally of liquid and solid aromatic hydrocarbons and contains some tar acids and tar bases; it is heavier than water and has a continuous boiling range beginning at about 200°C.

(continued on page 2)

Coal tar neutral oils are generally defined as a mixture of naphthalene, fluorene, anthracene, and other neutral hydrocarbons (Smale, 1977). Neutral hydrocarbons are those coal tar hydrocarbons other than coal tar acids (such as phenols, cresols, and cresylic acids), and coal tar bases (such as pyridines, quinolines, and acridines).

The actual constituents of coal tar, creosote, and the neutral oils are highly variable. They depend on the source of the coal used to produce the tar, the design and attendant operating conditions (temperature, coking time, gas collection systems) of the coke ovens, and in the case of the coal tar distillates the design and operating parameters of the still (e.g. the feed rate, temperature, and the blending of various tar distillate fractions) (Leach and Weinert, 1976).

Over three hundred compounds have been positively identified in coal tar. It is estimated that as many as ten thousand compounds may

1/ (continued from page 1)

The Condensed Chemical Dictionary (Hawley, 1977) defines cresosote as:

> A yellowish to dark brown, oily liquid; clear at 38°C or higher; naphthalenic odor; frequently contains substantial amounts of naphthalene and anthracene; distilling range 200-400°C; flash point 165°F (closed cup); soluble in alcohol, benzene, and toluene; immiscible with water. Combustible.

Von Rumker et al. (1975) defined creosote as a distillate of coal tar distilling in the temperature range 271-362°C, heavy creosote as distilling in the range of 285-395°C, and light creosote as distilling in the range of 238-291°C. Ross (1948) identified creosote oil as a distillate of coal tar distilling in the temperature range of 230-270°C.

exist, though many are present only in trace amounts (NIOSH, 1977). Because the composition of coal tar and coal tar products is known to vary, they are usually assayed and specified by their physical characteristics (including water content, specific gravity impurities, and fractional distillation curve). Using these physical characteristics, specifications for creosote used to pressure-treat wood have been established by the American Wood Preservers' Association, the American Society for Testing and Materials, and the United States General Services Administration (Appendix A). The American Wood Preservers' Association has also established specifications for creosote-coal tar solutions (Appendix B). About 98% of the creosote used for wood preservation in the United States is applied by pressure-treating methods (American Wood Preserver's Institute, 1977). Pressure-treating forces creosote to penetrate deeply into the wood.

B. Registered Uses, Production, and Supply

1. Uses

The largest pesticidal coal tar and creosote use is as a wood preservative. Coal tar is also used as an insect repellent, an acaricide, and a crow repellent. Creosote's other pesticidal uses are as an herbicide, an insecticide, an acaricide, an arachnicide, a fungicide, a tree dressing, a disinfectant, and a horse repellent. Coal tar neutral oil is registered as a disinfectant, a larvicide, an insecticide, a wood preservative, an arachnicide, an acaricide, and a fungicide. Specific uses and sites are given in Table 1.

2. Production and Supply

Von Rumker et al. (1975) reported that in 1972, 1,150 million

TABLE 1

USES AND SITES FOR COAL TAR, CREOSOTE, AND COAL TAR NEUTRAL OIL (Cummings, 1977)

Product	Use	Site
Coal Tar	Preservative	Wood
	Insect Repellent	Human Skin (Except Forehead)
	Acaricide	Dogs
	Crow Repellent	Seed Corn
Creosote	Preservative	Wood
	Insecticide (screwworm)	Horses and Mules
	Acaricide (mites)	Poultry Houses
	Arachnicide (ticks)	Poultry Houses
	Herbicide	Along Roads, Highways, and Fences; Lawns; Flower Beds
	Fungicide	Rope, Canvas, Tarpaulins, Tree Wounds
	Tree Dressing	Certain Insects, Worms, Moths and Borers
	Horse Repellent	Wood Stalls, Mangers, Gates, Fence Rails, Posts, Trees, Trailer Sides
	Disinfectant	Outhouses, Water Closets, Garbage Cans, Feeding and Watering Equipment
Coal Neutral Oil	Preservative	Wood
	Arachnicide (ticks)	Hog Houses; Sheep Barns; Dog Kennels; Horse Stables; Dogs.

TABLE 1
(continued)

USES AND SITES FOR COAL TAR, CREOSOTE, AND COAL TAR NEUTRAL OIL

Product	Use	Site
Coal Neutral Oil	Larvicide (mosquito)	Marshy Land; Stagnant Pools and Small Streams; Sewers; Drains; Small Non-fish Bearing Lakes and Ponds; Temporary Rain Pools; Rain Barrels; Clogged Gutters; Intermittently Flooded Areas; Tree Holes; Eaves; Canals and Ditches.
	Insecticide (srewworm)	Horses and Mules.
	Larvicide (gypsymoth)	Gypsy Moth Nests.
	Acaricide (mites)	Horses.
	Larvicide (fly)	Garbage Trucks.
	Insecticide (lice)	Horses; Dogs; Hog Houses; Sheep Barns; Dog Kennels; Horse Stables.
	Insecticide (fleas)	Hog Houses; Sheep Barns; Dog Kennels; Horse Stables; Dogs.
	Disinfectant	Soluble Cutting Oils for Machinery; Hog Houses; Sheep Barns; Dog Kennels; Horse Stables; Yards and Pens; Poultry Feeders; Waterers and Incubators; Boots; Animal Equipment and Utensils; Cellars; Sinks; Bed Pans; Washrooms; Garbage Cans and Pools; Homes; Factories; Offices; Schools; Public Buildings; Water Closets; Urinals; Spittoons; Sickroom Walls; Kitchens; Bathrooms; Lavatories; Woodwork and Floors; Wash Basins; Toilet Bowls and Seats; Livestock Trucks; Cotton Mills; Farrowing Equipment; Poultry and Meat Dressing Plants; Ships; Planes; Railroad Cars; Busses; Sick-room Thermometers; Dishes; Trays and Sputum Cups; Diaper Cans.
	Fungicide (ringworm)	Horses

pounds of creosote were used in the United States, of which 990 million pounds were domestically produced and 160 million pounds were imported. Of its total use, wood preservation accounted for 972 million pounds and fuel burning for about 178 million pounds. Fuller et al. (1977) reported that 96,266,000 gallons of creosote, approximately 843 million pounds, and 23,635,000 gallons of coal tar, approximately 238 million pounds, were used for wood preservation in 1975. Pesticide production data reported to the Environmental Protection Agency under Section 7 of FIFRA indicated that 34,847,384 pounds of coal tar, 366,839,110 pounds of creosote, and 2,019,951 pounds of coal tar neutral oil were formulated or blended for pesticidal use in 1975.

C. Fate in the Physical Environment

Little information is available in the literature regarding the environmental fate of coal tar and coal tar products used for purposes other than as wood preservatives. The following studies indicate that coal tar and creosote migrate to some extent from the treated wood into the surrounding environment. However, the impact of this migration is not known.

Leach and Weinert (1976) reviewed the literature on the loss of creosote from impregnated wood and found that the loss was dependent on many variables; among these are the kind of coal used to produce the coal tar, the kind of coke oven (temperature, coking time, and gas collection system) from which the coal tar is made, the distillation facilities and operating parameters (feed rate, temperature, and blend of various tar distillate fractions), the treatment and handling by the wood preservers

(seasoning and incising of the wood; temperature, pressure, and time of treatment; and the after-treatment cooling period) and the situations under which the wood is used (surface of wood exposed, orientation of the creosoted wood with reference to the wood grain, and the exposure environment).

1. Vapor Loss

Stasse (1964) found that the creosote vapor loss was greater from seasoned poles than from green poles. Vapor loss is also related to the temperature distillate fractions of the creosote; the higher the temperature of the distillate fractions, the lower the vapor loss. Over a three-year period, low residue (residue, in this study, was defined as the portion of creosote distillate over 355°C) creosote was found to have a vapor loss of 27.5% and 15.2%, from the outer 2 inches of seasoned and green poles, respectively; high residue creosote was found to have a 10.3% and 4.4% vapor loss, respectively.

2. Loss in a Marine Environment

Bramhall and Cooper (1972) found that the creosote concentration in the treated zone of pilings of a 40-year-old wharf averaged 15 pounds per cubic foot (74% of the current minimum) in the outer 1.5 inches. Whether the substandard retention was due to the original, treatment or to leaching could not be determined. Sweeney et al. (1958) found that creosote was lost from treated panels when wet due to the swelling of the wood fibers. Panels 5 x 1 1/2 x 1/8 inches were pressure-treated with creosote and exposed to flowing seawater at 25°C. Based on distillation analyses, approximately 30% of the creosote was lost in the first

month of exposure. By the twelfth month, approximately 40% of the creosote was lost. The rapid initial loss was attributed to the initial hydration of the wood fibers resulting in mechanical loss. It would be difficult to determine the loss of creosote from marine pilings based on the loss from small panels. This work, however, does indicate that coal tar-creosote may be lost from marine pilings by mechanical means, if not by true leaching.

Miller (1977) found that the ability of Douglas fir marine piles to retain creosote in cool estuarine waters was directly related to the density of the wood. Of the three piles studied, one had a detectable loss of about 0.31 pounds of creosote per linear foot of immersed pile during the first year, 0.05 pounds/year the second year, 0.06 pounds/year the third year, 0.22 pounds/year the fourth year, and an average of 0.15 pounds/year each year for the last 4 years of the 8-year study. Thus, in the first year a pile with 30 feet of its length in water would lose about 9.3 pounds of creosote, a daily loss of about 11.6 grams. The speed of the water flowing past the pilings was about 2 feet per second during flood tide and about 0.8 feet per second during ebb tide; upstream tide volume between the mean lowest and the mean highest daily tides was 900 million cubic feet of water. Miller concluded that because of the velocity and the volume of the water flowing past the pilings, the creosote lost from the pilings was greatly diluted. Hochman (1967) found that about 20% of the creosote initially impregnated into wood is expelled in the marine environment during the first year as a result of wood hydration. Stasse (1967) found a creosote displacement loss of 21.7% from wood panels

over a 6.5-year period in ocean water.

3. Loss in the Freshwater Environment

Nelso and Behr (1977) found that the greatest loss of creosote from round Southern Pine poles in fresh water occurred in the outer 0.5 inch zone where 48.1% of the creosote was depleted in 13 months. Overall losses for the 13-month period were 19.5%.

D. Fate in the Biological Environment

1. Microbial Degradation

Lean-Raymond and Bartha (1975) isolated six strains of bacteria from oil polluted estuarine water; all six grew on naphthalene, 2-methylnaphthalene, and 2-ethylnaphthalene. Phenanthrene and anthracene were metabolized by three of the six strains. Two of the six strains metabolized 1,5-dimethylnaphthalene and one strain metabolized 1-methylnaphthalene. Naphthalene, 2-methylnaphthalene, 2-ethylnaphthalene, 1-methylnaphthalene, and 1,5-dimethylnaphthalene have all been identified in creosote (National Research Council, 1945) (Lorenz and Gjovik, 1972).

Drisko and O'Neill (1966) found that the mixture of microorganisms present on creosoted pilings in the Port Hueneme, California harbor had the ability to metabolize creosote, causing loss of creosote from the pilings. Two of the aromatic hydrocarbons present in creosote - naphthalene and phenanthrene - were metabolized to a significant extent. *Pseudomonas creosotensis*, which was isolated from the mixture of microorganisms, utilized a number of neutral creosote constituents as a source of energy; conversely, acidic and basic creosote constituents inhibited its growth.

Hepner (1977) found that creosote in a soil to sand mixture (1:2)

was decomposed by soil microorganisms. Fertilized soil plots were watered weekly for 22 weeks with the equivalent of one inch of rain per week. Analyses showed that the leachates degraded rapidly when creosote concentrations in the soil were 0.1% or lower. Higher concentrations of creosote can be degraded in the soil but at a much lower rate (Hepner, 1977).

Davies and Evans (1964) studied the metabolism of naphthalene by a *Pseudomonas* species. The ultimate metabolic products were salicylaldehyde and acetaldehyde.

2. Bioaccumulation

Dunn and Stich (1975) showed that mussels taken from creosoted pilings contained significantly more benzo[a]pyrene (B[a]P), a known carcinogen (IARC, 1976), than those growing on other surfaces. B[a]P has been identified as a constituent of creosote oil (Lijinsky et al., 1963). Mussels taken from the creosoted wood showed mean B[a]P levels of 49 $\pm$ 5.8 ug/kg, while mussels taken from the same body of water but remote from the pilings showed mean contamination levels of 2.1 $\pm$ 0.3 ug/kg. Samples of creosote-treated wood pilings (outer 4 mm) showed B[a]P levels averaging 570 ppm. Thin-layer chromatograms of piling extracts and of mussels growing on these pilings showed "similar fluorescent band patterns" and may indicate that the creosote migrated from the pilings into the mussels.

Dunn and Stich (1976) also measured the B[a]P content of mussels attached to and near a partially creosoted wharf. Creosoted pilings served as a bumper system around a concrete wharf, and a barricade of creosoted timbers was placed at one end of the wharf. Mussels taken from rocks underneath and near the wharf were contaminated with creosote, rang-

ing from 54 to 78 ug/kg wet tissue weight; while those growing directly on the creosoted barricade were contaminated with 215 ug/kg, and those on rocks 1 meter from the barricade with 172 ug/kg. The authors suggested that the levels of B[a]P in mussels in this area are much higher than those generally found near creosoted structures and may reflect the age of the treated timber. The creosoted material at the wharf was relatively new and retained a tarry residue on its surface; mussels near older, weathered pilings should have much lower levels of B[a]P.

3. Effect on Freshwater Organisms

White (1975), in a study at a fresh water lake, compared an untreated pile, two pentachlorophenol-treated piles, an ammoniacal copper arsenate-treated pile, and a creosote-treated pile. After one month, the greatest number of algae species was growing on the surface of the creosote-treated pile. After one year all piles, except the one treated with ammoniacal copper arsenate, had extensive algal encrustment, along with many amphipods, limpets, and watermites entangled in the algal mats. Thus, creosoted piles did not affect the growth of attached freshwater organisms.

I. Regulatory History

Since 1968, various uses were cancelled and eliminated from the labels on coal tar and coal tar products. A summary of the cancelled uses follows:

February 1, 1968 - The U.S. Department of Agriculture (USDA) canceled the registrations of all products containing creosote used for disinfecting potato bins and other equipment used in potato production.

February 1, 1969 - USDA canceled the registrations of creosote and coal tar neutral oil-coal tar acid combination products used on beef cattle, goats, poultry, sheep, and swine.

February 26, 1970 - USDA canceled the registrations of products containing coal tar neutral oil-coal tar acid combinations used on dairy barns and the registration of products containing creosote used on animal sleeping quarters, barns, hog pens, and sheep folds.

March 12, 1971 - EPA canceled the registrations of coal tar neutral oil-coal tar acid combination products used on poultry houses.

II. Summary of Scientific Evidence Relating to Rebuttable Presumption

A. Oncogenicity

40 CFR Section 162.11(a)(3)(ii)(A) provides that "a rebuttable presumption shall arise if a pesticide's ingredient(s), metabolite(s), or degradation product(s)... induces oncogenic effects in experimental mammalian species or in man as a result of oral, inhalation, or dermal exposure..."

This discussion concerns only reports of the oncogenicity of coal tar, creosote, and coal tar neutral oil. Reports on the oncogenicity of soot, pitch, and petroleum, which have many constituents in common with coal tar, creosote, and coal tar neutral oil will not be discussed here.

In determining that the oncogenicity criterion was exceeded, the Working Group considered case reports of workers who were occupationally exposed to coal tar or creosote and who developed tumors, and reports of animal experiments in which mice, rats, or rabbits developed

tumors from either dermal or inhalation exposure to coal tar, creosote, or coal tar products. In addition, the Working Group considered conclusions by the Carcinogen Assessment Group (CAG) (CAG, 1977; CAG, 1978; McGaughy, 1978) that coal tar, creosote, and coal tar neutral oil are oncogenic.

Also, the Working Group is aware that a number of polycylic and heterocyclic aromatic hydrocarbons present in coal tar creosote and coal tar have been well established as carcinogens [International Agency for Research on Cancer (IARC), 1973; Freudenthal and Jones, 1976; Committee on Biologic Effects of Atmospheric Pollutants, 1972]. Specifically, IARC (1973) reported that the following constituents of coal tar or creosote were carcinogenic to animals by one or more routes of administration: benz[a]anthracene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[a]-pyrene, benzo[e]pyrene, chrysense, dibenzo[a,h]anthrancene, dibenzo[a,h]-pyrene, dibenzo[a,i]pyrene, indeno[1,2,3-cd]pyrene, benz[c]acridine, dibenz[a,h]acridine, and dibenz[a,j]acridine.

There may be differences in the chemical composition of the coal tars and coal tar derivatives in pesticide products subject to this presumption and the coal tar substances discussed in this section. If a registrant seeks to rebut the presumption on the ground that identified oncogens are not constituents of a particular pesticide product, the registrant should include relevant data on pesticide composition in the rebuttal submission.

1. Summary Table of Coal Tar, Creosote, and Coal Tar Neutral Oil Studies

Because of the numerous studies and reports on the oncogenicity of coal tar, creosote, and coal tar neutral oil, a summary table has been prepared and precedes the discussions of the studies (Table 2).

TABLE 2

SUMMARY OF COAL TAR, CREOSOTE, AND COAL TAR NEUTRAL OIL STUDIES

COAL TAR

Human Case Reports

Authors	Year	Substance and Type of Exposure	Occupation of Exposed Individual	Type of Tumor Response
Sharlaugh	1935	Coal Tar on repair needle held between lips	Fishermen - Net loft workers	Epidermal carcinomas of the lower lip
Mauro	1951	Handling of Coal Tar Pitch	Tar distillery workers	Cancer of skin, scrotum, cheek, and lip
Rosmanith	1953	Hot Coal Tar Vapors	Tar barrel filler	Spinocellular cancer in scar of cured erythematous lupus infection.

COAL TAR

Animal Studies
Dermal Exposure

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Yamagiwa & Ichikawa	1915	Coal tar	Rabbits (Strain Undefined)	Papillomas of the ear (site of application)
Tsuitsui	1918	Bituminous coal tar	Mice - English	Papillomas, carcinomas and spindle cell sarcoma
Kennaway	1925	Coal tar products of 450°C, 560°C, & 1,250°C distillation temperature.	Mice (Strain Undefined)	Skin tumors (higher rate of carcinogenesis at higher temperatures)

TABLE 2
(continued)

COAL TAR

Animal Studies
Dermal Exposure
(continued)

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Watson & Mellanby	1930	Dermal Application of coal tar following dermal application of fats, oils, or tannic acid	Mice (Strain Undefined)	Increased tumor production
		Coal tar dermal application combined with addition of butter to diet	Mice (Strain Undefined)	Higher incidence of lung nodules
Bonser & Manch	1932	Scottish blast furnace tar; English crude tar	Mice (Strain Undefined)	Papillomas and squamous cell carcinomas of the skin
Gorski	1959	Coal tar	Mice (Bn Strain)	Skin tumors (some malignant)
Hueper & Payne	1960	Coal tar	Mice - Black (C57 Strain)	Skin carcinomas
Horton	1961	Coal tars, coal tar mixture, benzo[a]pyrene mixture	Mice (C3M Strain)	Skin tumors in 75% of each group of animals
		Coal tar distillates	Mice (C3M Strain)	Skin tumors
Deelman	1962	Coal Tar	Mice (Strain Undefined)	Skin carcinomas and papillomas
Shabad et al.	1971	Coal tar ointments	Mice (C57 CBA Hybrid Strain)	Skin tumors

(15)

TABLE 2
(continued)

COAL TAR

Animal Studies
Inhalation Exposure

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Horton	1961	Coal tar fumes preceeded by inhalation of formaldehyde; coal tar fumes	Mice (C3M Strain)	Both groups developed proliferative alveolar neoplasia; one mouse (group unspecified) developed a squamous cell carcinoma
Horton et al.	1963	Coal tar aerosol; Coal tar aerosol & gaseous formaldehyde	Mice (C3H Strain)	Both groups developed squamous cell tumors of lung and lung adenomas
Tye & Stemmer	1967	Coal tar; coal tar & phenolic & non-phenolic fractions of coal tar; non-phenolic fractions of coal tar	Mice (C3H/HeJ Strain)	Adenomas & carcinomas of the lung
Kinkead; McConnell & Specht; MacEwen & Vernot	1972-1974	Aerosolized coal tar - light oil & solid fraction removed	Mice (ICR-CF1) Mice (JAX-CAF1) Weanling rats (Sprague-Dawley) Yearling rats (Sprague-Dawley) Hamsters (Syrian golden) Rabbits (New Zealand white)	Mice developed skin tumors due to aerosolized material deposited on skin; Tumor response was not reported for rabbits, hamsters, or rats
MacEwen & Vernot; MacEwen et al.	1976	Aerosolized Coal tar	Mice (ICR-CF1) Mice (JAX-CAF1) Rats (Sprague-Dawley) Rabbits (New Zealand albino) Monkeys (Macaca Mullata)	Mice - Alveolargenic carcinoma and skin tumors; Rats - Squamous cell carcinomas; No tumor response was reported for rabbits or monkeys.

(16)

TABLE 2
(continued)

CREOSOTE

Human Case Reports

Authors	Year	Substance and Type of Exposure	Occupation of Exposed Individual(s)	Type of Tumor Response
Mackenzie	1896	Handling of Creosote	Worker who dipped railway ties in creosote	Warty elevation on arms; Papillomatous swellings on scrotum
O'Donovan	1920	Handling of Creosote	Workers who creosoted timbers	Skin cancer
Cookson	1924	Handling of Creosote	Creosote factory worker	Squamous epithelioma on hand; epithelomatous deposits in liver, lungs, kidneys and heart walls
Henry	1947	Handling of Creosote	37 men of various occupations	Cutaneous epithelioma
Lenson	1956	Painting of Creosote	Shipyard worker	Malignant cutaneous tumors of the face

CREOSOTE

Animal Studies
Dermal Exposure

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Sall & Shear	1940	Creosote & Benzo[a]pyrene	Mice (Strain A)	Accelerated tumor formation
Woodhouse	1950	Creosote oil	Mice (Albino; Undefined Strain)	Papillomas & carcinomas
Lijinsky et al.	1956	#1 creosote oil	Mice - Swiss	Papillomas & carcinomas

(17)

TABLE 2
(continued)

CREOSOTE

Animal Studies
Dermal Exposure
(continued)

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Poel & Kammer	1957	Blended creosote oils;	Mice (C57L Strain)	Papillomas & carcinomas metastatic growths in lungs & lymph nodes
		Light creosote oil	Mice (C57L Strain)	Papillomas
Boutwell & Bosch	1958	Creosote (Carbasota)	Mice (Albino - random bred)	Papillomas & carcinomas
Roe et al.	1958	Creosote oil (Carbasota)	Mice (Strain Undefined)	Skin & lung tumors

COAL TAR NEUTRAL OIL

Animal Studies
Dermal Exposure

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Cabot et al.	1940	Benzene solution of neutral oil & benzo[a]pyrene	Mice - albino "market" mice	Inhibitory effect of tumor response as compared to tumor response with benzo[a]pyrene (effect credited to skin damage)
Berenblum & Schoental	1947	5 Coal tar neutral oil fractions	Mice (Strain Undefined)	All fractions but two were oncogenic
			Rabbits (Strain Undefined)	All fractions but one were oncogenic
Horton	1961	Coal tar neutral oils (maleic anhydride extracts)	Mice (Strain Undefined)	Produced tumors in 34.1 and 32.1 weeks

(18)

2. Coal Tar

a. Case Reports of Skin Cancer of Workers

Numerous reports of workers who developed cancer subsequent to coal tar exposure have been reported in the literature. The following is a summary of three of these case studies.

(1) Shambaugh

Shambaugh (1935) described his investigations of the incidence of cancer among fishermen and net loft workers who used and repaired tarred nets. Coal tar was used on nets to prevent them from rotting, and tar was often inadvertently smeared on the arms and face through use of the nets. Shambaugh's interest was prompted by the case of a patient who had sought medical help because of a growth on his neck. The growth was subsequently found to be an epidermal carcinoma involving the lymph nodes and invading the submaxillary gland. Closer examination of the patient additionally revealed a small, puckered scar on the lip, which the patient described as a "fisherman's sore." The patient had been a fisherman for 6 years, and while mending his nets he had held the tar-smeared needle between his lips at the spot where the growth developed. He had smoked a pipe but normally held it on the opposite side of his mouth. This case led Shambaugh to interview fishermen in Boston, Gloucester, New Bedford, and Provincetown, Mass. Using records of cases of cancer of the lip treated at Collis P. Huntington Memorial Hospital in Boston in 1932 and 1933, four fishermen with lip cancer were identified. Each had used tarred nets and at least one held the repair needle in the mouth on the side where the cancer developed. Tobacco was not used by this fisherman, but the other

three smoked pipes. Two of the three cancers developed on the opposite side of the mouth from where the pipe was held.

Among net loft workers, three cancer cases were reported. All held the repair needle in the mouth, and at least one of these workers did not use tobacco. Two had died of lip cancer, while one was treated successfully with radium.

The exposure to tar through net repair needles in the eight cases ranged from 5-60 years. All were epidermoid carcinomas of the lower lip.

(2) Mauro

Workers in a tar distillery were examined by Mauro (1951). Of a crew of 32, 20 had significant exposure to tar (14 day laborers, 4 distillers, and 2 stokers). All except the two stokers had some type of skin disorder; four of these were cancers. A 61-year-old distiller developed cancer of the scrotum after a 30-year exposure. Treatment with surgery and radiation was unsuccessful, and the patient died. A 50-year-old distiller, employed for 25 years, developed cancer of the scrotum and forearm. He was also treated with surgery and radiation, but the outcome was not stated. A 64-year-old day laborer developed cancer of the cheek after a 30-year exposure and was cured with radiation. A 53-year-old day laborer developed lip cancer after 22 years of exposure. He was treated successfully with radiation. The author stated that the workers were exposed to both tar and pitch, and that the two substances produce essentially identical cancers.

(3) Rosmanith

Rosmanith (1953) described the case of a worker who developed

skin cancer in the scar of a cured erythematous lupus infection. The patient had been employed for 10 years filling barrels with tar; while bending over the opening of the barrel, hot tar vapors had come in contact with his face. No protective gear was used other than gloves. The condition began at the root of the nose as several small solid growths which grew and expanded. The tumor was identified as a spinocellular cancer. Radiation treatment was unsuccessful.

b. Animal Studies - Dermal and Inhalation Exposure

The following 15 animal studies are presented chronologically. In general, they show that tumors were produced following dermal and inhalation exposure to coal tar. The Working Group notes that interpretation of some of the early studies is limited by the absence of control data. However, later studies which include appropriate control groups generally confirm and reinforce the observations in the early studies.

(1) Yamagiwa and Ichikawa

Yamagiwa and Ichikawa (1915) painted tar on the inner and outer surface and in open wounds of rabbits' ears. Seventy-one to 100 days following painting, papillomas were observed in 71% (12 of 17) of pairs of ears that had been painted on the inner surface. Papillomas were seen after 84 days in 17% (1 of 6) of rabbits' ears painted on the outer surface. Eighty-eight percent (7 of 8) of the ears painted on the inner surface had papillomas in rabbits surviving longer than 80 days. Only one papilloma was found in rabbits where the painting had been done on the outer surface or in a cut wound. The authors observed one eroded

papilloma (site unspecified) that had the appearance of a carcinoma, but were unable to examine the tumor histologically. The authors felt that the inner surface of the ear was more susceptible to the development of papillomas than the outer surface of the ear because there were fewer hair follicles. The author did not report using any controls.

(2) Tsutsui Study

Tsutsui (1918) studied the tumor response from bituminous coal tar applied to the skin of "strong" English mice. The tar was applied every third or fourth day. A total of 259 mice in seven groups were used; however, only 67 mice survived for 100 days. Tumors were examined histologically and photographed.

Papillomas developed in 48% (32/67) of the mice that survived 100 days. Later some of the papillomas developed into carcinomas, which invaded adjacent tissue, and were found in 24% (16/67) of the mice. A spindle cell sarcoma was found in one mouse, and lung metastases, confirmed on histological examination, were present in two mice. The author did not report using any controls.

(3) Kennaway

A study of coal tar products of 450°C, 560°C, and 1,250°C distillation temperatures showed a higher rate of carcinogenesis at the higher temperature fractions (Kennaway, 1925). The tars were applied to the interscapular region of 100 mice twice a week. After 230 days, 50% (10/20) had skin tumors in the 1,250°C-tar group, 34% (10/29) had skin tumors in the 560°C-tar group, and 4% (2/49) had skin tumors in the 450°C-tar group. Most tumors were malignant in the 1,250°C and 560°C groups. Nearly half the ani-

rals in the 560 °C and 1,250 °C groups had died by day 173, and more died as the experiment continued. The author did not report using any controls.

(4) Watson and Mellanby

A study reported by Watson and Mellanby (1930) tested the carcinogenic effect on mice (undefined strain) of the combination of fats in the diet with dermal application of coal tar, of the combination of the dermal application of various fats, oils, or tannic acid prior to the dermal applicaton of coal tar, and of the combination of pretreatment of skin with petroleum ether to remove some of the fatty substances with skin application of coal tar. Four groups of 70 mice were dermally pretreated twice each week with fats (extracted from either normal mouse tissue or from mouse tissue of mice who had died from tar-induced tumors), olive oil, or tannic acid (first applied in the experiment as a 10% solution and later in the experiment as a saturated solution). Coal tar was applied to the skin 30 minutes later. Control groups of the same size were treated only with coal tar. There were no controls in which healthy animals were used for comparison. The animals were treated for 120 days and were observed for a subsequent 240-day period except in the case of the olive oil group which was observed for 20 days subsequent to 90 days of application. Fats were added to the diet by the addition of butter to the food. The mice were fed a diet of one part powdered bread and one part Sussex ground oats made into a moist paste with water. This diet was fed daily and was supplemented once weekly with cod liver oil and marmite. Butter was added in amounts varying from 12.5-25% of the diet of the test mice. A control group consisted of mice to which no butter was

added to the diet but to which coal tar was dermally applied. There were no controls in which healthy animals were used for comparison. This experiment was done twice; once with 70 mice in both the test group and the controls and once with 90 mice in the test group and the controls.

Sixty male mice were treated with petroleum ether to remove at least some of the fatty substances in the skin. The petroleum ether (B.P. 60-80°C) was applied by means of a cotton-wool plug 30 minutes prior to the dermal tar application. This treatment was performed twice weekly for 120 days, and the mice were observed for an additional 330 days. A control group consisted of 60 male mice which were treated dermally with coal tar twice weekly for 120 days and then observed for 330 days. There were no controls in which healthy animals were used for comparison. An analysis of results of all the experiments is found in Table 3.

The application of tannic acid solution to the skin of mice prior to coal tar application did not affect incidence relative to the incidence produced by coal tar alone. The fat extracts or the olive oil, however, increased tumor incidence above the incidence produced by coal tar alone. Fat extracts from normal mice and from mice which had died from tar tumors increased tumor incidence to almost the same extent. Olive oil applied to the skin of mice prior to coal tar application resulted in a 72% lung tumor incidence among the skin tumor-bearing mice compared to 57% for controls (those treated with coal tar alone). The mice treated with fats or oils prior to tar treatment often developed tumors at several locations, which was not true of those treated with

TABLE 3

EFFECTS OF VARIOUS FATS AND OILS APPLIED DERMALLY OR IN THE DIET ON TUMOR INDUCTION BY COAL TAR (Watson and Mellanby, 1930)

Preconditioning	No. Tumors/ No. Animals	Percent of Tumor-Bearing Animals Developing Lung Tumors
I. Skin Treatments		
Experiment 1		
Tannic Acid	19/70 (27%)	47
Mouse Extract (Tumor-Bearing)	35/70 (50%)	63
Mouse Extract (Normal)	41/70 (59%)	59
Tar Only	18/70 (26%)	50
Experiment 2		
Olive Oil	29/70 (41%)	72
Tar Only	21/70 (30%)	57
II. Dietary Treatments		
Experiment 1		
Butter-fed	39/70 (56%)	60
No Butter	20/70 (29%)	37
Experiment 2		
Butter-fed	31/90 (34%)	55
No Butter	37/90 (41%)	41
III. Washing with Petroleum Ether		
Petroleum Ether (Wash)	19/60 (32%)	47
Tar Only	37/60 (62%)	61

tar alone. The addition of butter to the diet of two groups of mice led to a higher incidence of lung nodules in mice with tumors (60% vs. 37% and 55% vs. 41% in the two experiments), as compared to mice treated with tar with no dietary change. Butter-fed mice developed a greasy appearing coat. Mice washed with petroleum ether to remove some natural skin fats developed fewer skin tumors (32% vs. 62%), and fewer of those with skin tumors developed lung nodules than those mice treated with coal tar alone. The author concluded that addition of fats or oils to the skin or to the diet of mice prior to coal tar application caused more tar to be absorbed and thus increased tumor production. This conclusion was also supported by the reduction in tumor formation found when natural skin oil was partially removed by washing with petroleum ether.

(5) Bonser and Manch

Bonser and Manch (1932) studied the tumor response from application to mouse skin of three samples of Scottish blast-furnace tar, one sample of English crude tar, and an ether extract of the latter. The three samples of Scottish tar (I, II, and III) were made from coke-oven charges which contained in addition to the coal, 15-17%, 25%, and 10% coke, respectively; the English crude tar was made from a charge containing 75% coal and 25% coke. Sixty mice were used for testing each sample of tar. There was no control group. The hair was clipped away from a small area of skin in the region between the shoulder-blades. The tar was applied bi-weekly for the first 14 weeks, and thereafter once weekly because of marked ulceration of the skin of many mice. The study was continued for 56 weeks, by which time all the mice had died. Fifty-seven

tumors were grossly identified. Thirty-one of the total 57 tumors which had developed were confirmed histologically. Results appear in Table 4.

In mice treated with the three Scottish samples, the first tumors appeared at the 16th week. The Scottish I, II, and III tar samples produced a tumor incidence of 7/60 (12%), 10/60 (17%), and 8/60 (13%) respectively. The tumors were malignant in three mice. The first tumor appeared at the 21st week when an English crude tar was used. Eight mice (13%) treated with the English crude tar and 24 mice (40%) treated with an ether extract of the English crude tar developed tumors. Nine tumors in mice given the ether extract were malignant. At 30 weeks there were 25 survivors in the latter group of mice, and over 50% had tumors.

The tumors were papillomas or squamous cell carcinomas of the skin. The carcinomas invaded the muscle. One malignant tumor, seen after 47 weeks of application of ether extract of English tar, consisted of a mass of "mononuclear round cells" invading the adjacent muscle and fat and metastasizing to the lymph nodes.

In this study, blast-furnace tar obtained from a variety of sources induced benign and malignant tumors of the skin in mice. The carcinogenic properties were enhanced by extraction with ether.

(6) Gorski

Gorski (1959) investigated the carcinogenic properties of two coal tars (one produced from coal from the "Dobrek" mine and one produced from coal from the "Nowa Huta" mine), a soft pitch, a hard pitch, and an anthracene fraction. Thirty-2n mice about 2.4 months old and of approximately equal sex distribution were in each test group. The authors did

See 19A.

TABLE 4

INCIDENCE OF SKIN TUMORS IN MICE TREATED WITH BLAST FURNACE TARS
Carcinogen Assessment Group (CAG), 1978

Tar Sample	Number of Tumors per Number of Animals	Appearance of First Tumor (weeks)	Malignant Tumors
Scottish I	7/60 (12%)	16	0/60 (0%)
Scottish II	10/60 (17%)	16	2/60 (3%)
Scottish III	8/60 (13%)	16	1/60 (2%)
English Crude	8/60 (13%)	21	0/60 (0%)
Ether Extract of English Crude	24/60 (40%)	12	9/60 (15%)

not report using a control group. The mice were described as having a "low threshold for spontaneous growths." One drop of the test solution was applied to the skin near the backbone of the mice twice a week for 5 months, for a total of 44 applications per mouse. No data were provided on controls.

The test solutions were prepared by dissolving the materials in benzene (a 1:1 ratio). Pitch, being insoluble in benzene, was extracted using Soxhlet's apparatus, which provided a 1:5 solution in benzene.

Skin changes observed included peeling, swelling, and wart-like growths of differing shapes and sizes. Skin effects appeared earliest and with greatest intensity in the soft pitch group. Tumor results are reported in Table 5.

After 8 weeks, some mice had died in each group. Skin tumor observations were made at 4 months. Tar from the "Bobrek" mice produced an average of 0.6 tumors per mouse in 22 mice; 6 had malignant tumors. Eight of 26 surviving mice in the Nowa Huta mine tar group had malignancies, and there were, on the average, 0.2 tumors per animal. Twenty-one mice survived in the hard pitch group, with an average of one tumor per mouse; eight had malignant tumors. In the soft pitch group, 28 mice survived, with an average of 2.9 tumors each; 14 mice had malignant tumors. Of those to which an anthracene fraction was applied, 24 mice survived with an average of 0.3 tumors each; 4 mice had malignancies.

Mice with skin changes in all groups were debilitated and died by the end of the seven-month experiment. White hard growths ranging in size from that of a pinhead to that of a peppercorn were found by

TABLE 5

TUMOR PRODUCTION IN MICE DERMALLY EXPOSED TO NOWA HUTA COAL TAR, BOBREK COAL TAR, HARD PITCH, SOFT PITCH OR AN ANTHRACENE FRACTION
(Adapted from Gorski, 1959)

Product Tested	No. of Mice At Onset of Experiment	No. of Mice After Eight Weeks	Average No. of Tumors/mouse (after 4 months)	No. of Malignant Tumors Proven Histologically 1/
Bobrek Tar	30	22	0.6	6/22 (27%)
Nowa Huta Tar	30	26	0.2	8/26 (31%)
Hard Pitch	30	21	1.0	8/21 (38%)
Soft Pitch	30	28	2.9	14/28 (50%)
Anthracene Fraction	30	24	0.3	4/24 (17%)

1/ The denominator is the number of mice in that group alive after eight weeks.

dissection of the skin tumors, particularly in the later stages of the experiments. Other changes included enlarged lymph nodes, growths in the lungs, flaccidity of the liver, pale hard growths on the kidneys, and degeneration of the liver and kidneys. Metastases to the lymph nodes were confirmed in mice from the soft and hard pitch groups.

The author concluded that all the products tested were carcinogenic, that soft pitch was the most carcinogenic, anthracene fraction the least carcinogenic, and the two tars and the hard pitch were in an "intermediate" group.

(7) Hueper and Payne

Hueper and Payne (1960) found that skin tumors were produced in mice following the application of coal tar. Coal tar, four petroleum road asphalts (Venezuelan, Mississippian, Oklahoman, and Californian), one petroleum roofing tar, and paraffin oil were applied to the napes of the necks of groups of 50 black C57 mice (25 of each sex) for two years. An untreated control group consisted of 200 mice. So that the materials could be applied as droplets, the coal tar and roofing asphalt were heated to make them liquid, and the road asphalts were diluted with a sufficient amount of acetone. The paraffin oil was painted on the skin. Postmortem examinations were performed on all mice, and histological examinations were made of all tissues which exhibited gross abnormalities. The results are found in Table 6.

Carcinomas of the skin were found in 22 of 50 (44%) and papillomas in one of 50 (2%) mice receiving dermal applications of coal tar, whereas control mice did not develop tumors of the skin.

TABLE 6

SKIN TUMORS IN MICE GIVEN DERMAL APPLICATIONS OF COAL TAR, PETROLEUM ROOFING TAR, PARRAFIN OIL, OR PETROLEUM ROAD ASPHALTS
Carcinogen Assessment Group (CAG), 1978

Treatment	Skin Carcinomas		Skin Papillomas		Total	
Control	0/200	(0%)	0/200	(0%)	0/200	(0%)
Coal Tar	22/50	(44%)	1/50	(2%)	23/50	(46%)
Petroleum Roofing Tar	1/50	(2%)	0/50	(0%)	1/50	(2%)
Paraffin Oil	1/50	(2%)	1/50	(2%)	2/50	(4%)
Petroleum Road Asphalt						
Venezuelan	0/50	(0%)	0/50	(0%)	0/50	(0%)
Mississippian	1/50	(2%)	1/50	(2%)	2/50	(4%)
Oklahoman	0/50	(0%)	1/50	(2%)	1/50	(2%)
Californian	1/50	(2%)	0/50	(0%)	1/50	(2%)

Hueper and Payne also administered some of the substances via inhalation and intramuscular injection. Coal tar did not produce lung tumors in rats or guinea pigs inhaling such fumes for periods up to two years but did produce muscle sarcomas following intramuscular injection. The results of the intramuscular study are not discussed here because intramuscular injection is not a route of exposure included in the criteria of 40 CFR 162.11(a)(3)(ii)(A).

(8) Horton

In several experiments Horton (1961) tested a number of crude coal tars, coal tar distillates, and fractions of coal tar for skin tumor response in C3M mice. In the first part of the study, five coal tars (four from the coking of bituminous coal and one from the coking of lignite coal), a mixture of one of the bituminous coal tars in 50% benzene, and a benzo[a]pyrene mixture were tested. The authors did not report using a control group. No data were provided on the number of mice tested nor on the length of time the animals were treated; however, the time-to-tumor for each group was reported. The incidence of tumors was reported to be greater than 75% (only a percentage was reported) for each test group. Horton developed a numerical index designed to grade the various tars and tar fractions for relative carcinogenic potency. This index was referred to as the potency for a minimum concentration of material (PMC). A high PMC value is meant to indicate a greater carcinogenic potency. For tars D-1 and D-613 for which multiple doses were applied, a dose response was evident. The mean time-to-tumor (in weeks), the schedule of application, and the PMC values for each of the tars, the tar solu-

TABLE 7

MEAN TIME-TO-TUMOR AND PMC VALUES FOR FOUR BITUMINOUS TARS, ONE LIGNITE TAR, AND ONE SOLUTION OF BENZO[a]PYRENE (Adapted from Horton, 1961)

Treatment	Schedule of Application (#/week - mg)	Mean Time-to-Tumor (weeks)	PMC
D-1 - bituminous tar	2-10	15.6*	0.27*
	2-50	12.6*	0.37*
	3-100	7.0*	0.63*
D-4 - bituminous tar	2-10	24.8	0.13
D-5 - bituminous tar	2-10	23.6	0.14
D-5A - 50% dilution by weight of D-5 tar	2-10	25.1	0.13
D-8 - bituminous tar	3-50	21.9	0.11
D-12 - lignite tar	3-50	17.1	0.16
D-613 - benzo[a]pyrene in 85% beta-methylnapthalene and 15% benzene solution	2-15	33.0*	0.08*
	2-50	30.6*	0.10*

* The multiple doses for Tars D-1 and D-613 demonstrated a mean time-to-tumor and a PMC dose responses.

tion, and the benzo[a]pyrene solution are reported in Table 7.

Two tars from the previous group (D-1 and D-8) were chosen to test the effect of skin washing with a detergent in water 5 or 60 minutes after tar application. Tars D-1 and D-8 had the highest (0.8) and lowest (0.1) benzene-insoluble content, respectively. Washing delayed tumor development, but the final tumor incidence was not significantly changed. The delay was greater in the animals washed 5 minutes after dermal application.

Horton also determined the relationship between the amount of benzo[a]pyrene in distillates of coal tar and the carcinogenic potency of those distillates. Tar D-1, a distillate oil of D-1 (the first 9-13.5% of the distillation), a proportionate reblend of nine distillate fractions of D-1, and two distillate fractions (a carbolic oil and a light creosote oil) of a coal tar (D-9) not previously used in the experiments were tested for B[a]P content and carcinogenic potency (PMC) to the skin of mice. With the exception of Tar D-1, all test materials were applied to mice (strain unspecified) in 10 mg doses. Tar D-1 was applied in 20 mg doses. The number of applications was described as "repeated," but neither the frequency nor the duration was specified. The PMC values and benzo[a]pyrene content of the test substances are reported in Table 8.

Comparison of the benzo[a]pyrene content with the carcinogenic potencies of various fractions showed that no tumors were produced by those fractions in which no benzo[a]pyrene could be detected, while the carcinogenic potency of the test materials that contained benzo[a]pyrene was correlated with their content by weight of this carcinogen. Despite this observation, the authors did caution that these results do not imply that benzo[a]pyrene is the only carcinogen in these substances.

(35)

TABLE 8

PMC VALUES AND BENZO[a]PYRENE CONTENT FOR TWO COAL TARS, SEVERAL DISTILLATES OF THOSE COAL TARS, AND A PROPORTIONATE REBLEND OF THE DISTILLATES FROM ONE OF THE TARS

Test Material	Doses (mg)	Content of Benzo[a]pyrene (%)	Relative Carcinogenic Potency (PMC)
Tar D-1	20	0.74	0.27
Distillate Oil of Tar D-1	10	0.01	0.01
Proportionate Reblend of the Nine Cuts of Tar D-1	10	0.08	0.11
Carbolic Oil of Tar D-9	10	0.00	0.00
Light Creosote Oil of Tar D-9	10	0.00	0.00

(36)

(9) Deelman

Deelman (1962) studied the effect of time between tar applications on tumor development. He found that papillomas developed after 18 applications regardless of the interval between applications (2 to 7 days). The number of carcinomas was small after 18 applications. In time, after the end of the applications, however, many of the papillomas became carcinomas.

When tar was applied to different size skin areas or fields, it was found that mice with the largest field (20 x 25 mm) had an average of one carcinoma and seven papillomas each. Eight mice, with a tarred field of 2.5 x 25 mm (The coal-tarred area for the eight mice combined is equal to the largest field tested or 20 x 25 mm field for one mouse.) had a total of 34 papillomas and three carcinomas among them. It was found that among the tar fields tested (20 x 25 mm, 10 x 25 mm and 2.5 x 25 mm), the smaller the tar field, the larger the number of tumors per unit area. This may be a result of the greater toxicity to the animals with the larger tar fields; the author observed that mortality, weight loss, and kidney damage increased as the size of the tar field increased. No untreated controls were used in the study.

(10) Shabad et al.

Shabad et al. (1971) applied three coal tar ointments [Loracorten tar ointment (USA), CIBA coal tar ointment (Switzerland), and coal tar ointment (USSR)] to C57 CBA hybrid mice two or three times each week for 10 or 12 months to test for tumor production. The authors did not report using any control groups. All of the mice died within 18 months or were sacrificed because of their poor condition. Eighteen of 19 (94.7%), 20 of 21 (95.2%), and 16 of 17 (94.1%) of the animals in USSR, CIBA, and Loracorten ointment groups, respectively, developed tumors. The benzo [a]pyrene content of the three ointments was 225, 5,020, and 5,190 ug/g, respectively. Shabad also tested the effect of two birchwood tar ointments, Vishnevsky and Tashkent, on groups of 20 and 24 C57CBA mice. None of the mice in the groups develped tumors after 18 months. The benzo[a] pyrene contents of the Vishnevsky and Tashkent tars were 0.0013 and 0.044 ug/g, respectively.

(11) Horton

Horton (1961) studied the lung tumor response in C3H mice after exposure to coal tar fumes. One group of mice inhaled formaldehyde-contaminated air intermittently for an unspecified amount of time, while a second group was kept in clean air. The former group developed squamous metaplasia as a result of their exposure to formaldehyde. Both groups were then exposed to coal tar fumes (0.33 mg/liter) for one hour/day, three days/week for 13 to 33 weeks. A majority of the mice (numbers were not reported) in both groups developed proliferative alveolar neoplasia, and one (the group was not reported) developed a squamous cell carcinoma. The two groups of mice showed no difference in neoplasia incidence. A third group of mice, exposed intermittently to formaldehyde alone for 64 weeks, showed no alveolar proliferation or carcinoma development.

(12) Horton et al.

Horton et al. (1963) examined C3H mice (a strain that was reported to have a low historical incidence of spontaneous pulmonary adenomas) for lung tumors following inhalation exposure to coal tar aerosol, gaseous for-

maldehyde, or gaseous formaldehyde followed by coal tar aerosol. In the first part of the experiment, groups of 60, 60, and 42 mice were exposed to concentrations of 0.5, 0.10, or 0.20 mg/liter, respectively, of gaseous formaldehyde for three 1-hour periods per week. The control group consisted of 59 untreated mice. After 35 weeks, none of the animals that were sectioned of those that died (118 of 221) during the 35-week period had developed lung tumors. The surviving animals were used to conduct further experiments with coal tar and formaldehyde. The surviving 33 mice from the control group in the first part of the experiment and the surviving 26 mice from the group in the first part of the experiment that had been exposed to 0.10 mg/l of gaseous formaldehyde were exposed to 0.30 mg/l of coal tar aerosol for three 2-hour periods per week for up to 36 weeks. The surviving 36 mice from the group that had been exposed to 0.05 mg/l of formaldehyde in the first part of the experiment were exposed to 0.15 mg/l of formaldehyde for three 1-hour periods each week for up to 35 weeks. There was also an untreated control group[1/] which was observed for 82 weeks.

The test animals were exposed to the test substances until death; the first death occurred 1 to 11 weeks after exposure and the longest time until death was 36 weeks. Serial sections of the trachea, large bronchi, and lung from the exposed animals and from the lungs of 30 unexposed mice were examined (Table 9).

1/ The initial size of the untreated group was not reported. At the termination of the experiment at 82 weeks, the group consisted of 30 mice.

TABLE 9

TUMORS OF THE LUNG IN MICE INHALING FORMALDEHYDE AND/OR AEROSOL OF COAL TAR
Carcinogen Assessment Group (CAG), 1978

Treatment	Squamous Cell Tumors	Adenomas	Total
(-)	0/30 (0%)	0/30 (0%)	0/30 (0%)
Coal Tar	6/33 (18%)	1/33 (3%)	7/33 (21%)
Formaldehyde and Coal Tar	1/26 (4%)	1/26 (4%)	2/26 (8%)
Formaldehyde	0/36 (0%)	0/36 (0%)	0/36 (0%)

Five mice inhaling coal tar aerosol and one mouse inhaling formaldehyde followed by coal tar developed squamous cell tumors in the periphery of the lung, involving 1/3 to 1/2 of the lobe. In two mice from the former group, several lobes were involved. A sixth mouse in the former group that died after 20 weeks of exposure had an invasive squamous cell carcinoma, which was described as "unquestionably a squamous cell carcinoma whereas those occurring in the other five animals probably represented an earlier stage of development at the time of death." One mouse in each group had adenoma of the lung. Tumors of the lung were not observed in mice breathing formaldehyde only or in untreated controls.

There were other changes produced in the tracheobronchial epithelium as the result of the inhalation of coal tar. The most striking was a necrotizing tracheobronchitis in the majority of mice; the incidence was not reported. In addition, squamous cell metaplasia extended into the smaller bronchi. Hyperplasia of the bronchial epithelium occurred frequently, sometimes with papillary infolding. The epithelium of untreated mice was normal showing neither metaplasia nor hyperplasia.

Epithelial changes in mice inhaling formaldehyde involved mostly the trachea; extension into the major bronchi was infrequent and did not occur at all in the smaller bronchi. In general, the inhalation of formaldehyde resulted in an acute tracheobronchitis ranging from slightly to severely necrotizing, or developing into a chronic type with proliferation of fibrous tissue. This was sometimes complicated by bronchopneumonia. In summary, mice inhaling coal tar aerosol developed squamous cell carcinomas of the lung, as well as hyperplastic and metaplastic epithelial changes.

(13) Tye and Sterner

Tye and Sterner (1967) separated two different coal tars into phenolic (P-tar) and nonphenolic (N-tar) fractions and exposed mice by inhalation to various blends of the coal tar fractions and to one of the original tars. The same coal tar (T-1) (Specific gravity 1.17, 4.5% tar acid, 0.7% benzo[a]pyrene and 67% Diels-Adler compounds) that was used in the experiments by Horton, Tye, and Sterner (1963) and a second, somewhat different tar (T-2) (Specific gravity 1.24, 1.4% tar acid, 1.1% benzo[a]pyrene, and 2% Diels-Alder compounds), were the two tars from which the phenolic (P-tar) and nonphenolic (N-tar) fractions were separated.

Fifty male C3H/HeJ mice, three to five months old, were in each test group. The tests groups consisted of untreated, Tar-1, N-Tar-1, N-Tar-1 plus P-Tar-1, N-Tar-1 plus P-Tar-2, and N-Tar-2 plus P-Tar-1. Mice were exposed for two hours every three weeks. During the first eight weeks, the exposure was at a concentration of 0.20 mg/l, but this was reduced to 0.12 mg/l because so many mice died.

Three mice from each group were killed after four weeks, and five mice were killed after 31 weeks. Surviving mice were killed at the end of 55 weeks. Mortality from exposure was high in all groups of treated mice. At the end of the experiment, there were 31/50 (62%), 11/50 (22%), 11/50 (22%), 10/50 (20%), 21/50 (42%), and 21/50 (42%) mice alive in the control, Tar-1, N-Tar-1, N-Tar-1 plus P-Tar-1, N-Tar-1 plus P-Tar-2, and N-Tar-2 plus P-Tar-1 groups, respectively. Tumor response is recorded in Table 10.

The most prominent lesions were intrabronchial adenomas and ade-

TABLE 10

INCIDENCE OF LUNG TUMORS IN MICE INHALING AEROSOLS OF COAL TARS 1/
Carcinogen Assessment Group (CAG), 1978

Treatment	Metaplasia		Adenomas 2/		Adenocarcinomas		Adenomas & Carcinomas	
(-)	0/32	(0%)	0/32	(0%)	0/32	(0%)	0/32	(0%)
Tar-1	5/13	(38%)	12/13	(92%)	3/13	(23%)	13/13	(100%)
N-Tar-1	2/20	(10%)	16/20	(80%)	0/20	(0%)	16/20	(80%)
N-Tar-1 + P-Tar-1	5/19	(26%)	14/19	(74%)	1/19	(5%)	15/19	(79%)
N-Tar-1 + P-Tar-2	7/25	(28%)	14/25	(56%)	1/25	(4%)	15/25	(60%)
N-Tar-2 + P-Tar-1	4/23	(17%)	14/23	(61%)	0/23	(0%)	14/23	(61%)

1/ Mice surviving for 46 weeks or longer.

2/ Includes intrabronchial and alveolar adenomas.

nocarcinomas, occurring anywhere in the bronchial tree. Multiple tumors were frequently seen. The intrabronchial adenomas were papillary. There also were alveloar adenomas which were peripheral. Tumors of the lung were diagnosed as adenocarcinomas only if there was invasion or if metastases were observed.

Adenomas and carcinomas of the lung were observed in 60% to 100% of the mice inhaling aerosols of coal tars, whereas tumors were not seen in any of the control mice. Incidences of squamous metaplasia varied from 10% to 38% in treated mice and were absent in control mice. "Alveolar epithelization" was also observed, but less often than squamous metaplasia. Areas of squamous and alveolar metaplasia were not considered as tumors, even when they occupied relatively large spaces.

(14) Kinkead, McConnell and Specht, and MacEwen and Vernot

MacEwen and Vernot (1972-1974), Kinkead (1973), and McConnell and Specht (1973) reported on a study in which mice, rats, hamsters, and rabbits were exposed to a coal tar aerosol from which the light oil and solid fraction was removed. Gross skin pathology for the mice was reported; any other tumor response in the mice and in the other animals was not reported. 1/

Groups of 64 female yearling and 64 weanling (32 of each sex) Sprague-Dawley rats, 50 male JAX-CAF1 mice, and 50 male ICR-CF1 mice were

1/ Per contractual agreement, Sasmore performed internal and skin histopathology for the study and reported his results (Sasmore, 1976), but because information in the Sasmore report is incomplete, no conclusions can be made about the report.

exposed continuously for 90 days (except for 15 minutes a day to allow for animal maintenance) to concentrations of 0.2, 2.0, and 10.0 mg/m^3 of coal tar aerosol. Eighty-two female yearling Sprague-Dawley rats, 82 weanling Sprague-Dawley rats (73 female and 9 male), 75 male JAX-CAF1 mice, 75 male ICR-CF1 mice, 100 male golden Syrian hamsters, and 24 New Zealand white rabbits were exposed continuously, as above, for the same 90-day period to a concentration of 20 mg/m^3. The control animals consisted of 41 female and 41 male Sprague-Dawley weanling rats, 82 female Sprague-Dawley yearling rats, 75 male JAX-CF1 mice, 75 male ICR-CF1 mice, 24 female New Zealand white rabbits, and 100 male golden Syrian hamsters (Lachman and Vernot, 1972). Many of the mice contracted a streptococcus infection and died before 93 days post exposure. Skin tumor response for the mice is found in Table 11.

Tumor responses of 28% (10 of 36), 38% (3 of 8), and 8% (2 of 25) were seen in the three highest dose groups of the ICR-CF1 mice; no tumors (0 of 62) were found in the controls. A tumor response of 37% (10 of 27) was found in the highest dose group in the JAX-CAF1 mice; no tumors (0 of 74) were found in the JAX-CAF1 controls. McConnell and Specht (1973) examined some of the skin tumors histologically and concluded that a whole spectrum of epithelial tumors, from squamous cell papilloma to keratoacanthoma, to "frankly aggressive" appearing squamous cell carcinoma are stimulated by the coal tar aerosol, although the majority of these tumors fall in the squamous cell carcinoma category. McConnell and Specht also found a time-to-tumor dose response for the coal tar aerosol. This dose response is shown in Table 12. As stated above, tumor response was not reported for the rats, hamsters, or rabbits.

TABLE 11

TUMOR RESPONSE IN MALE ICR-CF1 AND JAX-CAF1 MICE FOLLOWING EXPOSURE COAL TAR AEROSOL (Adapted from McConnell and Specht, 1973)

Dose (mg/m^3)	ICR-CF1 1/		JAX-CAF1 1/	
20.0	10/36	(28%) 2/	10/27	(37%) 2/
10.0	3/8	(38%) 3/	0/12	(0%) 3/
2.0	2/25	(8%) 3/	0/47	(0%) 3/
0.2	0/2	(0%) 3/	0/47	(0%) 3/
0.0	0/62	(0%) 2/	0/74	(0%) 2/

1/ The numerator is the number of animals with tumors at 415 days post exposure. The denominator is the number of animals that were alive at 93 days post exposure.
2/ This dose group began with 75 animals.
3/ This dose group began with 50 animals.

TABLE 12

LATENT PERIOD OF FIRST TUMOR INDUCTION IN CTV-I EXPOSED ICR-CF1 MICE (McConnell and Specht, 1973)

Dose (mg/m^3)	Time of Tumor Appearance (Days)
20	< 93
10	128
2	142

(15) MacEwen and Vernot, and MacEwen et al.

MacEwen and Vernot (1975 and 1976) and MacEwen et al. (1976) reported on two studies of the tumor response of mice, rats, rabbits, and monkeys following exposure to coal tar aerosol. In the first study, 80 female Sprague-Dawley yearling rats, 80 Sprague-Dawley weanling rats (40 males and 40 females), 75 JAX-CAF1 male mice, 75 ICR-CF1 male mice, and 100 male golden Syrian hamsters were exposed continuously for 90 days (except for 15 minutes a day to allow for animal maintenance) to concentrations of 0.2, 2.0, and 10.0 mg/m^3 of coal tar aerosol. An equal number of each species were used for controls. The coal tar used to generate the aerosol in this study was:

> a composited mixture collected from multiple coking ovens around the greater Pittsburgh area. The coking ovens were of several different types and used different coal sources for their starting materials. The coke oven effluents were collected in air collection devices using a chilled water spray to condense the higher boiling distillate fractions. After settling and separation of the liquid phase, the various coal tar samples were blended together with a 20% by volume amount of the BTX (benzene; toluene; xylene) fraction of the coke oven distillate.

An aerosol particle size determination in the exposure chambers was performed, and it was found that a minimum of 97% of all droplets were in a respirable range of five microns or less in diameter. Only skin tumor response for the mice was reported (Table 13). Tumor response was not reported for the hamsters or rats.

In the second study 75 female and 100 male ICR-CF1 mice (described as tumor susceptible), 50 female JAX-CAF1 mice (described as a tumor resistant hybrid strain), 40 male and 40 female CFR strain Sprague-Dawley wean-

TABLE 13

SKIN TUMOR RESPONSE IN ICR-CF1 AND JAX-CAF1 MICE FOLLOWING EXPOSURE TO COAL TAR AEROSOL (MacEwen and Vernot, 1976)

Dose (mg/m^3)	Week of Observation 2/	Cumulative Number of Tumors 1/ ICR-CF1 Exposed	ICR-CF1 Control	JAX-CAF1 Exposed	JAX-CAF1 Control
10	100	44/75 (59%)	3/75 (4%)	18/75 (24%)	1/75 (1%)
2	103	14/75 (19%)	0/75 (0%)	3/75 (4%)	0/75 (0%)
0.2	101	1/75 (1%)	0/75 (0%)	1/75 (1%)	1/75 (1%)

1/ The numerator is the number of animals with tumors; the denominator is the number of animals exposed.

2/ Includes the 90-day exposure period.

ling rats, 18 New Zealand albino rabbits, and 5 male and 9 female Macaca mulatta monkeys were exposed to 10 mg/m^3 of coal tar aerosol for 6 hours each day, five days per week for 18 months. The coal tar used to generate the aerosols in this study was the same as that of the first study. Aerosol particle size was determined monthly in the exposure chambers. A minimum of 99% of the total droplets in both chambers were 5 microns or less in diameter and were thus within a respirable size range for rodents.

Exposure to the coal tar at 10 mg/m^3 significantly reduced the body weight of rabbits and rats compared with the controls, whereas monkeys showed no significant change in body weight. Sixteen of 18 rabbits and six control mice died during the test period. These deaths were attributed to a chronic respiratory infection which caused debilitation and dehydration. At the conclusion of the exposure period, the test monkeys and the surviving test rabbits along with the unexposed controls were delivered to the NIOSH Laboratories in Cincinnati, Ohio, for long-term post-exposure observation, but the results were not reported in MacEwen et al. (1976). Discussion with MacEwen indicated that while the monkeys are still under observation, the number of surviving rabbits (2 of 18) was too few for statistical comparison, and those animals were sacrificed (Gibb, 1978a). No tumor response was found in the sacrificed rabbits (Gibb, 1978b).

Alveolargenic carcinomas were produced in 26 of 61 (43%) ICR-CF1 mice and in 27 of 50 (54%) JAX-CAF1 mice. The number of tumors in the ICR-CF1 and the JAX-CAF1 control mice were 3 of 68 (4%) and 8 of 48 (17%), respectively. The exposed and control groups did not differ in the incidence of other types of tumors including squamous cell carcinomas, lymphosarcomas, subcutaneous sarcomas, alveolargenic adenomas, bronchiogenic carcinomas, reticulum cell sarcomas, hemangiosarcomas, and hemopoietic tumors.

Skin tumors were produced in 5 of 75 (7%) of the ICR-CF1 mice and 2 of 50 (4%) of the JAX-CAF1 mice as compared to 3 of 75 (3%) and 1 of 50 (2%) in the ICR-CF1 and JAX-CAF1 controls, respectively. The criterion for counting a lesion as a skin tumor was a growth greater than 1 mm in diameter and in height. Each tumor was ultimately confirmed by histologic examination. MacEwen et al. compared the lack of skin tumor response in the second study to the tumor response of the 10 mg/m^3 dose group of the first study. As stated previously, the first study found a skin tumor incidence of 44 of 75 (59%) in the treated ICR-CF1 mice and 18 of 75 (24%) in the treated JAX-CAF1 mice as opposed to only three of 75 (4%) in the ICR-CF1 controls and 1 of 75 (1.3%) in the JAX-CAF1 controls, respectively. A calculation of total exposure time (MacEwen et al.,1976) revealed that the same amount of coal tar aerosol reached the skin of the mice in the second study as in the first study. MacEwen et al. suggested that the 18 months' intermittent exposure of the animals in their study allowed the animals enough time each day to permit normal cleaning of the fur.

The incidence of coal tar tumorigenesis in rats is reported in Table 14.

The incidence of squamous cell carcinomas in the lungs was (36/36) 100% in exposed males and (31/38) 82% in exposed females as opposed to 0 of 36 (0%) in male controls and 0 of 37 (0%) in female controls.

A dose-related tumor response was observed for both the ICR-CF1 and the JAX-CF1 mice.

TABLE 14

COAL TAR TUMORIGENESIS IN RATS
(MacEwen, 1976) et al.

	Controls		Exposed	
	Males	Females	Males	Females
Number Examined Histologically 1/	30	37	38	38
Number of Rats with Tumors:				
Squamous Cell Carcinoma, Lung	0	0	38	31
Squaceous Cell Carcinoma	0	1	0	0
Intraabdominal Carcinoma	0	1	0	0
Mammary Fibroadenoma	0	1	0	3
Mammary Adenocarcinoma	0	1	0	0
Other Tumors	0	1	8	2
Overall Tumor Incidence (%)	0	13	100	82

1/ The original number of rats per group was 40. However, because of autolysis and/or cannibalization, a few animals were unsuited for histopathological examinations.

Many aromatic hydrocarbons such as those found in coal tar are known to fluoresce. Hide (skin and hair) tissue samples taken during the exposure period from the ICR-CFl mice in the second experiment were extracted with toluene and analyzed for fluorescent content. Results are found in Table 15. Hide fluorescence during exposure correlated with the tumor response.

3. Creosote

Reports of workers who developed cancer subsequent to creosote exposure have been reported in the literature. The following is a chronological summary of these reports.

a. Case Reports of Skin Cancer in Workers

(1) Mackenzie

Mackenzie (1890) reported the case of a man employed for 30 years dipping railway ties in liquid creosote in an air-tight chamber. The worker stated that only his arms and hands came into contact with the dripping planks. In several places on his forearms, there were "skin elevations of a warty character about the size of split peas." On the right half of the patient's scrotum were several papillomatous swellings from the size of a pea to that of a nut, rather soft but covered with a horny crust and sore to the touch. The patient had picked several off, leaving a bleeding surface. The author suggested that the tumors were likely to become epithelioma tous.

(2) O'Donovan

O'Donovan (1910) lists three cases of skin cancer of men occupationally exposed to creosote; two of the men creosoted wood, and one pickled wood in creosote. O'Donovan detailed the case of one man who

TABLE 15

SUMMARY OF HIDE FLUORESCENCE (ug/cm^2) OF ICR-CF1 MICE DURING AND AFTER EXPOSURE TO COAL TAR AEROSOL

Dose (mg/m^3)	Days of Exposure 1	7	30	60	90	30 Days Post-Exposure	ICR-CF1 Mouse Skin Tumors at 100 Weeks
10.0	26.9	34.9	19.2	23.8	21.6	0	44/75 (59%)
2.0	2.4	9.3	7.6	4.4	9.9	0	14/75 (19%)
0.2	0.4	1.6	4.9	1.0	3.8	0	1/75 (1%)

(53)

had been creosoting timber for 40 years. Warts had appeared on his hands, legs, and behind his ears seven years prior to reporting his case. The warts had fallen off and left scars behind them. Eighteen months before the case was reported, a wart on the patient's scrotum had fallen off, leaving a small sore which never healed and steadily enlarged. Three months before admission to the hospital, the glands of the left groin enlarged; the patient steadily lost weight and grew weaker. On admission to the hospital, the case was considered inoperable.

(3) Cookson

Cookson (1924) reported on a worker employed for 33 years to carry creosoted wood. At least 15 years before the case was reported, a small swelling appeared on the back of the worker's right hand. The swelling would occasionally break open and then heal again. About 7 years later, the swelling increased substantially in size until the growth had to be removed. A portion was examined histologically prior to being excised and proved to be a squamous epithelioma. Following the patient's death several years later, an autopsy was performed, and small secondary epitheliomatous deposits were found in the liver, both lungs, and in both kidneys. There were also two secondary deposits in the heart walls. One in the left ventricular wall involving its whole thickness was the size of a walnut and was beginning to break down in the interior. The other was the size of a pea at the right border of the right ventricle.

(4) Henry

Henry (1947) reviewed 753 cases of cutaneous epitheliomata reported to the British Medical Inspector of Factories from 1920 to 1945

(54)

and found 37 cases attributable to creosote exposure. Of these cases 14 occurred among workers treating timber, 9 among people handling creosote in storage, and 10 among people using creosote as a releasing agent for brick molds. One case of epithelioma was reported among workers using creosote for the manufacture of furnace crucibles, and one case among workers manufacturing creosote disinfectants. The author also reports two cases of cutaneous cancer not reported to the British Medical Inspector of Factories: a railway platelayer handling creosoted ties and an assistant chemist testing creosote for 16 months in a tar distillery laboratory.

(3) Lenson

Lenson (1956) described a shipyard worker who had worked with creosote for three years. Malignant cutaneous tumors of the face appeared 5 years after working with the creosote. The worker had been a painter for 41 years and had mixed his own paints, using lead and oils. Turpentine and white gasoline had been used as paint removers.

b. Animal Studies

The following 6 animal studies are presented chronologically. In general they show that tumors were produced following dermal exposure to creosote. As with coal tar, the Working Group notes that the interpretation of some of the early studies is limited by the absence of control data. However, later studies which include appropriate control groups generally confirm and reinforce the observations in the early studies.

(1) Sall and Shear

Sall and Shear (1940) reported on several experiments which tested

the potential of the basic fractions of creosote to accelerate tumor production by known carcinogens. Female Strain A mice obtained from the Roscoe B. Jackson Memorial Laboratory in Bar Harbor, Maine, were used in all the experiments which included administration by skin painting and subcutaneous injection. In the skin painting experiments a mixture of 1% basic creosote and either 0.02% or 0.05% benzo[a]pyrene was applied three times per week to the treated animals. Concentrations of benzo[a]pyrene, at 0.02% and 0.05% were used alone for two control groups; another control group was painted with 1% basic creosote alone. There were no control groups in which healthy animals were used for comparison. The results of the skin painting experiments indicated that the basic fraction of creosote accelerated the tumor formation when applied with either 0.02% or 0.05% benzo[a]pyrene concentration, although the basic creosote alone produced no tumors. The results of the intramuscular experiment are not discussed here because intramuscular injection is not a route of exposure included in the criteria of 40 CFR 162.11(a)(3)(ii)(A).

(2) Woodhouse

Woodhouse (1950) studied the carcinogenic activity of 16 petroleum fractions and extracts, anthracene oil, creosote oil, linseed oil, pine tar, and six spindle oils dermally applied to 50 groups of ten-week-old, albino mice (undefined strain). Each test substance was applied with glass rods to the intrascapular area twice weekly for 25 weeks. Males and females were tested in approximately equal numbers. The animals surviving 25 weeks in each test group were counted, and papillomas and carcinomas were identified. Of the creosote-treated animals, 19 survived 25 weeks; 19 tumors (10

papillomas and 9 carcinomas) were reported. This was the highest number of tumors in the 10 treatment groups tested. There was no control group.

(3) Lijinsky et al.

A study by Lijinsky et al. (1956) evaluated creosote and its basic fracton as possible tumor-promoting agents. The experiment failed to demonstrate that creosote acts as a strong promoter when administered to mice receiving a single painting of 7,12-dimethylbenz[a]anthrancene (DMBA), but it did demonstrate that creosote is independently carcinogenic.

The creosote used was a "#1 oil, dry point 240 °C, collected as a distillation fraction from a Wilton still." The basic fraction was prepared by the procedure of Cabot et al. (1940). Treatments were given twice weekly for 70 weeks to four groups of 30 female Swiss mice. A single drop of the treatment solution was applied with a glass dropper to the intrascapular region of the skin, which was kept free of hair by clipping with scissors. A control group (Group 1) consisting of 50 mice was treated with the initiating agent, 7,12-dimethylbenz[a]anthrancene (DMBA) given as a 1% solution in mineral oil. Group 2 was painted with undiluted creosote. The three remaining groups received a single initial painting of 1% DMBA in mineral oil; one week later they were treated with undiluted creosote (Group 3), 10% creosote in acetone (Group 4), or a 2% basic fraction of creosote solution in acetone (Group 5). There were no control groups in which healthy animals were used for comparison.

The tumor incidence in the five groups is shown in Table 16. The survival rate of the control animals given DMBA alone was not given; whatever their number, none of them were reported to have developed tumors.

TABLE 16

SKIN TUMOR INCIDENCE IN MICE TREATED WITH CREOSOTE
Carcinogen Assessment Group (CAG), 1977

Group	Initial Painting	Twice Weekly Painting	Incidence of Tumor-Bearing Mice 1/	Nos. of Papillomas	Nos. of Carcinomas	Average Latent Period (weeks)
1	1% DMBA	None	0/50 (0%)	0	0	0
2	None	Creosote: undiluted	13/26 (50%)	7	16	50
3	1% DMBA	Creosote: undiluted	17/23 (74%)	6	26	39
4	1% DMBA	Creosote 10% in Acetone	11/29 (38%)	7	8	43
5	1% DMBA	Creosote: 2% Basic Fraction	0/12 (0%)	0	0	0

1/ In group 1 there were 50 animals initially. In groups 2, 3, and 4 the denominator is the number of survivors at time of appearance of first tumor. In group 5 there there were 12 survivors at 56 weeks.

In contrast, there was a high tumor rate for animals pre-treated with DMBA and then treated repetitively with either undiluted or 10% creosote. Some enhancement of the action of a single initiating dose of DMBA was noted when given with undiluted creosote (50% vs. 74%), although the difference was not significant. Dilution of the creosote to 10% in acetone diminished the tumor producing action of DMBA plus creosote, while the basic fraction did not prove to be oncogenic.

In a companion study (Lijinsky et al., 1956) the creosote was chemically analyzed for benzo[a]pyrene, but less than 100 mg of benzo[a]pyrene was found per liter of creosote, an amount the authors consider too small to account for the carcinogenic activity of creosote. They suggested that some of the carcinogenic activity may result from the presence of benz[a] anthracene which was found in a relatively large quantity (2.75 gm/liter).

The results of this study showed that undiluted creosote alone produced a carcinogenic effect which was slightly augmented by the initial DMBA treatment. When the creosote was diluted to 10% the promoting action was somewhat diminished in relation to the undiluted creosote. The basic fraction of creosote at a 2% strength was inactive. The authors reported that the carcinogenic potential of the undiluted creosote was comparable to results found with DMBA, a potent carcinogen, in a similar test conducted at the same laboratory.

(4) Poel and Kammer

Poel and Kammer (1957) tested two "creosote oils" for carcinogenic potential on male and female mice. In the introduction to their report, Poel and Kammer described the difference between the definitions of coal

tar fractions as they are classically defined and coal tar fractions as they are industrially used:

> The crude industrial fractions distilled from high-temperature coal tars are designated light oil, middle oil or napthalene crude cut, heavy creosote oil, anthracene oil and pitch (Table 17). A clear cut separation of tar into these distinctive fractions is usually not practiced on an industrial scale. In fact, such terms as creosote, heavy oil, and anthracene oil have been used synonymously, while certain industries to this day designate some pitches as "tars". Most of the marketed oil products are blends or smears, containing both creosote and anthracene oils plus varying amounts of the residual fractions from the middle-oil cut - the fraction shown in Table 17 to have a boiling range of 200 to 250°C.

The two "creosote oils" used in the study were described by Poel and Kammer as follows:

> Both are fractions from a high-temperature horizontal by-product-coke-oven tar. One is a crystal-free oil, marketed as a blend of creosote, anthracene oils, and the oil drained from the naphthalene recovery operation. This blend of oils has been described as non-toxic to humans and is used principally for the preservation of wood.... The second sample, considered a light creosote oil industrially [Table 17] is the residual oil drained from the naphthalene recovery operation.

The blended sample was tested in toluene at two dilution levels, 20% and 80%; the light creosote oil was tested at a 50% dilution in toluene. As a positive control, benzo[a]pyrene was tested in toluene at two dilution levels, 0.05% and 0.25%. Toluene was tested as a negative control.

The test animals were C57L mice, females, 10 to 12 weeks old and males 8 to 11 weeks old. The test solution was applied three times per week on the shaved back of each mouse for its lifespan or until persis-

TABLE 17

CRUDE COAL TAR DISTILLATES (POEL AND LAMPER, 1957)

Industrial Cut	Approximate Distillation Range (°C)	Fraction Recovered From Tar (%)	Principal Components of Fraction
Light Oil	200	5	Benzene, Toluene, Xylene, Solvent Naphtha
Middle Oil	200-250	17	Tar Acids, Tar Bases, Naphthalene, Light Creosote oil (residue)
Creosote Oil (Heavy)	250-300	7	Methylated Naphthalenes, Acenaphthene
Anthracene Oil	300-350	9	Fluorene, Phenanthrene, Anthracene, Carbazole
Pitch	> 350	62	Pitch Oil, Carbon

tent papillomas developed at the application site. Results of the test are found in Table 18.

These results show a significant increase in tumor incidence after topical treatment with both concentrations of blended creosote as compared to the incidence produced by the toluene control. All mice exposed to both dilutions of the blended creosote oil developed papillomas, and 7 of the 8 in each dilution group developed carcinomas. Among the creosote-treated animals that developed carcinomas, 5 of 14 had metastatic growths in the lungs and/or the regional lymph nodes. The 50% solution of light creosote oil in toluene produced tumors in all 11 male C57L-mice tested, after exposure ranging from 22 to 41 weeks. It was not reported whether the tumors were malignant or not. The presence of benzo[a]pyrene was tested for in light creosote oil and in the anthracene fraction of the blended creosote oil (where it most likely would be found). Detectable levels were not observed, and the authors concluded that the tumor response seen was due, at least in part, to other agents.

In summary, dermal application of light and blended creosote oils from high-temperature-coke-oven-tars induced significant increases in skin tumors on mice. Most of the tumors from the blended oil were carcinomas.

(5) Boutwell and Bosch

In a study which evaluated the tumor initiating and promoting activity of several chemicals, including creosote, and the carcinogenic potential of creosote without the use of initiating or promoting agents, Boutwell and Bosch (1958) found that creosote was carcinogenic when ap-

TABLE 18

TUMOR INDUCTION IN C57L MICE TREATED WITH BLENDED CREOSOTE, LIGHT CREOSOTE, BENZO[a]PYRENE, AND TOLUENE 1/

Test Material	Conc. in Toluene(%)	No. Mice with Tumors	No. Mice with Epidermal Cancer	No. Mice with Metastasis
Creosote Blend	80	8/8 (100%) 2/	7/8 (88%) 3/	3
Creosote Blend	20	8/8 (100%) 2/	7/8 (88%) 3/	2
Light Creosote	50 5/	11/11 (100%) 4/		
Benzo[a]pyrene	0.25	8/8 (100%) 2/	8/8 (100%) 2/	2
Benzo[a]pyrene	0.05	8/9 (89%)	7/9 (78%)	1
Toluene Control	0.0	0/10 (0%)	0/10 (0%)	0

1/ Female C57L mice were used in all groups except light creosote which used males.

2/ Significantly higher than controls ($p = 2.3 \times 10^{-5}$).

3/ Significantly higher than controls ($p = 2.5 \times 10^{-4}$).

4/ Significantly higher than controls ($p = 2.8 \times 10^{-6}$).

5/ The light creosote oil was administered as one drop of 50% (in toluene) creosote oil along with one drop of toluene.

plied to mouse skin, and that it had the ability to initiate tumor formation when applied for a limited period prior to treatment with croton oil. The mice used in the test were 8-week old, random-bred female albino mice.

The creosote was tested at full strength as obtained from Barrett Chemical Company. The trade name of the oil is Carbasota. It is described as "fractions distilled from a high temperature coke-oven-tar in the boiling range of 200 to over 400°C." Croton oil and DMBA used in the study were dissolved in re-distilled benzene. Solutions were protected from exposure to light and evaporation.

The solutions were applied as a 25 ul drop to the shaved skin of the back. Mice were inspected for tumors weekly and papillomas larger than 1 mm in diameter were counted. The gross identification of both benign and malignant tumors was confirmed periodically by microscopic examination.

There were 30 female mice in each group. The group applications were as follows: (Group 1) one drop (25 ul) of undiluted creosote twice-weekly with no initial treatment; (Group 2) one application of 75 ug DMBA followed (one week later) with 25 ul of benzene twice-weekly; (Group 3) single applications of DMBA as in Group 2, followed after one week with twice-weekly applications of 25 ul undiluted creosote; (Group 4) same initial treatment as in Groups 2 and 3 but followed with twice-weekly applications of 25 ul of a 0.5% croton oil in benzene solution; (Group 5) croton oil alone with no pre-treatment; (Group 6) undiluted creosote twice-weekly for four weeks only with no secondary treatment; (Group 7) undiluted creosote twice-weekly for four weeks followed with croton oil

as in Groups 4 and 5. There were no controls in which healthy animals were used for comparison. The length of observation of each group was determined by the carcinogenic response (Table 19).

Papillomas and carcinomas developed in all groups given creosote except Group 6, where the duration of treatment may not have been long enough. Comparison of the results from Groups 6 and 7 show that creosote can act as an initiating agent prior to the application of croton oil. Pre-treatment with DMBA slightly reduces the induction time of tumors produced by repeated continuous creosote administration.

(6) Roe et al.

Roe et al. (1958) found that animals receiving dermal applications of creosote developed tumors of the skin and the lungs. The study consisted of two experiments. Two to three-month old mice were obtained from a commercial breeder for the first experiment. Prior to treating with creosote, the authors observed a total of 788 lung adenomas on the lobe surface of the lungs of 138 mice (an average of 5.8 adenomas per mouse) at 6-8 months of age. Since the commercial breeder had used creosoted wooden boxes to house the animals, it was determined that the lung adenomas were the result of housing the animals in these boxes. Some of these mice were allowed to breed in steel cages in the laboratory. The resulting progeny were found to have an average of only 0.5 adenomas per animal. Two groups of the fourth generation of the original mice were used in the first experiment. One group was bred in stainless steel cages and 24 of the resulting progeny (Group 1) were kept as untreated controls for eight months. Twenty-five progeny (Group 2) were treated twice-weekly

TABLE 19

SCHEDULE OF TREATMENTS AND TUMOR INCIDENCE IN MICE EXPOSED TO DMBA AND CREOSOTE

Group	Initial Treatment	Secondary Treatment (2x/wk)	Period of Treatment and Observation (wks)	Induction Time Carcinomas (wks)	Incidence of Carcinomas (%) 1/
1	None	Creosote	28	26	82 2/
2	75 ug DMBA	Benzene	56		
3	75 ug DMBA	Creosote	28	23	82 2/
4	75 ug DMBA	Croton Oil	54	36	80 3/
5	None	Croton Oil	44		
6	Creosote, 4 weeks, (2x/wk)	None	44		
7	Creosote, 4 weeks, (2x/wk)	Croton Oil	56	44	46 4/

1/ For groups 1,3,4, and 7, only percentages were reported; no carcinoma percentages were reported for Groups 2, 5, or 6.
2/ This incidence was recorded at 28 weeks.
3/ This incidence was recorded at 42 weeks.
4/ This incidence was recorded at 44 weeks.

on the backs with one drop (25 ul) of creosote oil (Carbasota) from the age of three weeks until six months and were observed for two months longer. The Carbasota was produced by the Barrett Chemical Company and was described as "a material in the boiling range of 200°C to over 400°C distilled from a high temperature coke-oven-tar." Progeny from the second group of the fourth generation mice were bred in wooden cages which were "thoroughly impregnated with creosote oil." They produced 29 young (Group 3). Group 3 mice were kept in the cages for the duration of the experiment and were treated for five months with one drop (25 ul) of creosote oil (Carbasota) applied twice-weekly after which they were kept for three months without treatment. After eight months Group 1 had an average of less than 0.5 adenomas per mouse. Group 2 had almost six per mouse and Group 3 almost 11 per mouse (Table 20, Experiment 1). Groups 2 and 3 together totaled 53 mice. Of this number, 5 bore skin tumors but no lung tumors; nine had lung tumors but no skin tumors; and 39 bore both skin and lung tumors. The incidence of skin and lung tumors in the controls was not given; therefore, a statistical analysis of the control versus the experimental groups is not possible. However, the total number of lung adenomas in Groups 2 and 3 was greatly increased over those of the controls (Group 1).

In the second experiment, random-bred albino mice were obtained from a supplier who used only metal cages for breeding. The control group (Group 1) of 50 animals consisted of two groups from a related study (Boutwell and Bosch, 1958), in which one group was treated initially with 75 ug of DMBA followed by a twice-weekly application of 25 ul of a 0.5% solution (w/v) of croton oil in benzene; and the other group

TABLE 20

THE EFFECTS OF CREOSOTE TREATMENT ON THE INCIDENCE OF LUNG ADENOMAS (Carcinogen Assessment Group, 1977)

Experiment	Group	Treatment	No. of Mice	Adenomas on Lung Surfaces	Adenomas per Mouse
1	1	None (control)	19	9	0.5
	2	One drop of creosote 2 times/week for 23 weeks	24	139	5.8
	3	One drop of creosote 2 times/week for 19 weeks in creosoted Cages	29	315	10.8
2	1	Initial treatment with 75 ug of DMBA followed by one drop of croton oil or benzene 2 times/week for approximately 55 weeeks (control)	50	15	0.3
	2	One drop of creosote 2 times/week for 4 weeks.	23	37	1.6

was treated initially with 75 ug of DMBA followed by a twice-weekly application of 25 ul of benzene. No untreated controls were used. The test group of 30 animals (Group 2) was treated twice-weekly for four weeks nine times) with one drop (25 ul) of creosote oil and thereafter kept under observation without further treatment. At 10 months 15 adenomas were seen in the 50 survivors of Group 1. On the other hand, the 23 survivors of Group 2 bore a total of 37 lung tumors (Table 20, Experiment 2). No skin tumors were reported for any of the mice in Experiment 2.

4. Coal Tar Neutral Oil

No human studies were found on coal tar neutral oil. The following three animal studies on coal tar neutral oil are presented chronologically.

(1) Cabot et al.

Cabot et al. (1940) painted albino "market" mice with benzene solutions of various creosote oil fractions together with benzo[a]pyrene. The fractions of creosote were prepared from a creosote oil obtained from a vertical-retort coal tar; 90% of the creosote oil distilled between 160 °C and 300 °C (Fraction 1). The basic constituents were first removed from creosote with aqueous hydrochloric acid (Fraction II); the phenols were removed with aqueous sodium hydroxide (Fraction III). The remaining neutral material (Fraction IV) was steam distilled, producing "neutral distillate" or neutral oil (Fraction V), and leaving the "neutral residue " (Fraction VI). The six fractions were dissolved in benzene containing either 0.2% or 0.05% benzo[a]pyrene. These solutions were painted on groups of 20 mice three times weekly for 20 weeks. Thereafter, the

solutions containing 0.2% benzo[a]pyrene were applied twice-weekly for six additional weeks. With the solutions containing 0.05% benzo[a]pyrene, the the painting was continued three times per week for an additional 18 weeks. When a papilloma appeared, painting was continued until the skin growth attained an average diameter of about 4 millimeters. Control groups were painted with benzene solutions containing either 0.2% or 0.05% benzo[a] pyrene. No untreated controls were used.

Skin tumors occurred sooner and with greater incidence in animals tested with the high benzpyrene concentration than with the low concentration treatments. Four of the fractions had lower rates of tumor formation than the rates produced by benzo[a]pyrene alone. These four fractions were the parent creosote mixture, the phenolic fraction, the concentrated neutral distillate, and the neutral residue. The authors attributed the inhibitory effect of all but the phenolic fraction to skin damage, but suggested further experiments on the inhibition mechanism of phenolic fractions. Of the two promoting fractions, only the basic fraction had an enhancing effect at both benzo[a]pyrene concentrations.

(2) Berenblum and Schoental

Berenblum and Schoental (1947) extracted a horizontal-retort gas tar[1/] with light petroleum, then removed basic and acidic constituents by shaking with dilute HCl followed by dilute NaOH. The remaining neutral

1/ Although gas tar is made from coal, it is somewhat different from bituminous coking operation coal tar which is used for pesticide production in the United States. The Working Group, however, decided that the physical and chemical characteristics of the two are similar enough to make the results of this study relevant.

fraction was chromatographed and five coal tar neutral oil fractions were separated:

I. All bands up to and including anthracene
II. After anthracene, before benzo[a]pyrene
III. Benzo[a]pyrene bands
IV. Fluorescence bands 391, 412, and 430 mu
V. Fluorescence bands at 385 mu, and residue

The fractions were tested dermally on groups of 10 mice and 5 rabbits, for periods of 17-28 weeks, and were applied once a week on mice and twice a week on rabbits. No untreated controls were used. Fraction II was oncogenic to rabbits (5/5), but not to mice (0/11), Fractions III and IV were oncogenic to both rabbits (5/5 and 4/5, respectively) and mice (7/10 and 3/10, respectively). Fraction V did not produce tumors in mice or rabbits. The results of Fraction I were not reported. None of the crystals obtained from any of the fractions were oncogenic to mice or rabbits, which suggested that the oncogenicity of the fraction remained in the mother liquor.

(3) Horton

As discussed earlier, Horton (1961) evaluated the carcinogenic potential of coal tar and several coal tar fractions including coal tar neutral oil. In separating the coal tar fractions, coal tar acid was extracted with a 9% aqueous solution of sodium hydroxide from filtered benzene solutions of two different coal tars. The raffinates from this sodium hydroxide extraction of the tars were mixed with celite, agitated with concentrated HCl, and then filtered. The tar bases remained on the celite as solid hydrochlorides. The tar fractions from which the acids

and bases had been removed were subjected to repeated contact with maleic anhydride in benzene solution at 80°C to extract the neutral anthracene-type of hydrocarbons (the neutral oils). The adducts formed with maleic anhydride were mixed with powdered soda-lime, and the neutral oil was regenerated by short path distillation at a dull red heat at atmospheric pressure. The remaining residue after extraction of the tar acids, the tar bases, and the neutral oil hydrocarbons was called the residual tar. The tar acids and the tar bases were dissolved in benzene at a concentration equivalent to their concentrations in the original coal tar. The maleic anhydride fraction (the neutral oil) was tested in a 1% solution of benzene. The residual crude tars were tested at 100% concentration; in addition, one of the crude tars was tested at a 50% concentration in benzene.

Ten-mg doses of the two coal tars and the diluted coal tar were dermally applied twice-weekly to mouse skin (the number and strain of mice tested was not stated), and 10-mg doses of the fractions and residual tars were applied three times per week. No untreated controls were used. The time of the tumor appearance was noted, and the relative carcinogenic potency of the different test substances was calculated on the basis of differences in time-to-tumor. This index was referred to as the potency for a minimum concentration of material (PMC). A high PMC value means a greater carcinogenic potency. Skin tumors appeared most quickly from the residual and crude tars: 24.8 and 23.6 weeks and 18.4 and 13.4 weeks from their respective residual tars. No tumors were reported from the acidic fractions of either tar. The basic fractions

of the two tars produced tumors in 48.6 and 40.6 weeks, respectively, and the coal tar neutral oils (maleic anhydride extracts) from the two tars produced tumors in 34.1 and 32.1 weeks. The PMC values indicated that the residual and crude tars were most carcinogenic, with calculated values of 0.14 and 0.22 for the residual tars and 0.13 and 0.14 for the crude tars. PMC values for the coal tar neutral oils were 0.05 and 0.06; the PMC values for the basic fractions were 0.03 and 0.04. Since no tumors were produced by the acidic fractions, PMC values were not calculated.

5. Conclusion

a. Coal Tar

Shambaugh (1935), Mauro (1951), and Rosmanith (1953) reported on fishermen and net loft workers, tar distillery workers, and a tar worker, respectively, who had been occupationally exposed to coal tar and who had developed skin cancer. In animal studies, dermal application of coal tar produced skin tumors with mice [Horton (1961), Shabad et al. (1971), Watson and Mellanby (1930), Tsuitsui (1918), Hueper and Payne (1960), Deelman (1962), Bonser and Manch (1932), Gorski (1959), and Kennaway (1925)], and rabbits [Yamagiwa and Ichikawa (1915)]. Inhalation exposure to coal tarr produced lung tumors in mice [Horton (1961), MacEwen et al. (1976), Horton et al. (1963), and Tye and Stemmer (1967)], and rats [MacEwen et al. (1976)]. Exposure of mice to coal tar aerosol also produced skin tumors (McConnel and Specht, 1973; and MacEwen et al. 1976).

Horton (1961) found a dose response for skin tumors in mice following dermal application of coal tar. McConnell and Specht (1973) and

MacEwen and Vernot (1976) found a dose response for skin tumors in ICR-CF1 mice following inhalation exposure to coal tar aerosol. Horton (1961) and McConnell and Specht (1973) also found that the time-to-tumor was dose-related.

The Working Group concludes that coal tar produced tumors in three species of animals: mice, rats, and rabbits; that tumor response and time-to-tumor in the Horton (1961), McConnell and Specht (1973), and MacEwen and Vernot (1976) studies were dose-related; and that workers occupationally exposed to coal tar developed tumors. The Working Group thus concludes that coal tar is an oncogen and that it exceeds the criteria of 40 CFR 162.11(a)(3)(ii)(A). Accordingly, the Agency is issuing a rebuttable presumption against all pesticides containing coal tar.

b. Creosote

Henry (1947), Lenson (1956), O'Donovan (1920), Cookson (1924), and Mackenzie (1898) described various kinds of workers who were occupationally exposed to creosote and developed skin tumors. Dermal application of creosote produced skin tumors in mice [Woodhouse (1950), Poel and Kammer (1957), Lijinsky et al. (1956), Boutwell and Bosch (1958), and Roe et al. (1958)]. Roe et al. (1958) also found that dermal application of creosote to mice produced lung tumors. Boutwell and Bosch (1958) found that creosote had the ability to initiate tumor formation when applied for a limited period prior to treatment with croton oil. Sall and Shear (1940) found that the number of skin tumors was increased by dermal treatment with creosote and benzo[a]pyrene over the number of tumors produced by benzo[a]pyrene or creosote alone. The Working Group con-

cludes that creosote produces tumors in mice; that creosote, when applied dermally, is a tumor-initiating agent when followed by dermal treatment with croton oil (Boutwell and Bosch, 1958); that creosote accelerates the tumor production caused by benzo[a]pyrene (Sall and Shear, 1940); and that workers occupationally exposed to creosote developed tumors. The Working Group concludes that creosote is an oncogen and exceeds the criteria of 40 CFR 162.11 (a)(3)(ii)(A). Accordingly, the Agency is issuing a rebuttable presumption against all pesticides containing coal tar.

c. Coal Tar Neutral Oil

Horton (1961) found that dermal application of coal tar neutral oil to mice produced skin tumors. Berenblum and Schoenthal (1947) found that several chromatographic fractions of coal tar neutral oil produced skin tumors when dermally applied to mice. Cabot et al. (1940) found that mixtures of coal tar neutral oil with benzo[a]pyrene decreased the number of tumors produced by benzo[a]pyrene alone, but suggested that this inhibiting effect was due to skin damage. The Working Group concludes that coal tar neutral oil produces tumors in mice, and that as an oncogen, it exceeds the criteria of 40 CFR 162.11(a)(3)(ii)(A). Accordingly, the Agency is issuing a rebuttable presumption against all pesticides containing coal tar neutral oil.

B. Mutagenicity

40 CFR 162.11(a)(3)(ii)(A) provides that "a rebuttable presumption shall arise if a pesticide's ingredient(s), metabolite(s), or degradation product(s)... induces mutagenic effects, as determined by multitest evidence."

In determining that this criteria was exceeded, the Working Group considered reports by Simmon and Poole (1978) and Mitchell and Tajiri (1978) who examined a creosote mixture of American Wood Preservers' Association (AWPA) specification P-1 and a coal tar-creosote mixture of AWPA specification P-2, Class C. The AWPA specifications for P-1 and P-2, Class C, are found in Appendices A and B. P-1 creosote is used for foundation piles, fresh-water piles, telephone poles, utility poles, fence posts, and other land and fresh-water uses. Class C P-2 coal tar-creosote is used primarily for railroad ties (Gibb, 1978c). *In vitro* microbiological assays with four strains of *Salmonella typhimurium*, TA 1535, TA 1537, TA 98, and TA 100, and *Escherichia coli* WP2 (Simmon and Poole, 1978) and *in vitro* mammalian cell bioassays with L5178Y mouse lymphoma cells (Mitchell and Tajiri, 1978) were conducted on both of the coal tar-creosote mixtures.

1. Simmon and Poole

Simmon and Poole (1978) conducted *in vitro* microbiological mutagenic assays on P-1 and P-2 using *Salmonella typhimurium* and *Escherichia coli* strains. These microbiological assays were conducted both with and without metabolic activation. Metabolic activation was provided by use of an Arochlor 1254-stimulated rat liver homogenate. Metabolic activation provides metabolic steps that the bacteria either are incapable of conducting or do not carry out under the assay conditions.

The Salmonella strains used were all histidine auxotrophs. They included: Strains TA 1537 and TA98 which are sensitive to frameshift mutations, TA 1535 which is sensitive to base-pair substitutions, and TA 100 which is sensitive to base-pair substitutions and some frameshift mutations. The *E. coli* WP2 strain is a tryptophan auxotroph and is sensitive to base-

pair substitutions. The results of the mutagen tests on P1 and P2 are found in Table 21.

Except at the higher doses which were toxic, creosote P1 and coal tar-creosote P2, Class C, when metabolically activated, demonstrated a mutagenic dose-response and a doubling over the background level in the bacterial assay with Salmonella typhimurium strains TA 1537, TA 98, and TA 100. S. typhimurium strain TA 1535 and E. coli strain WP2 did not demonstrate a positive mutagenic response with metabolic activation. None of the strains demonstrated a positive response without activation. The fact that a mutagenic dose-response was found in the TA 1537, TA 98, and TA 100 S. typhimurium strains indicates that the mutagenic mode of action of the creosote and the creosote-coal tar mixture is by frameshift mutation.

2. Mitchell and Tajiri

Mitchell and Tajiri (1978) tested creosote of AWPA specification P1 and a coal tar-creosote mixture of AWPA specification P2, Class C, for mutagenic activity on an in vitro mammalian mutagenesis assay using L5178Y mouse lymphoma cells heterozygous at the thymidine kinase (TK) locus. The purpose of the test was to determine the effects of the P1 and P2 mixture on the forward mutation frequency of the TK locus, $TK^{+/-} \longrightarrow TK^{-/-}$, relative to the background level. Similar to the microbial assay described above, the mouse lymphoma study was conducted both with and without metabolic activation using an Arochlor 1254 stimulated rat liver homogenate mixture.

The mouse lymphoma cells were grown in suspension culture. The

TABLE 21

IN VITRO ASSAYS SALMONELLA TYPHIMURIUM AND ESCHERICHIA COLI
(Simmon and Poole, 1978)

Sample	Metabolic Activation	Amount of Sample Added Per Plate (ug)	Average Number of Revertants Per Plate: S. typhimurium TA1535	TA1537	TA98	TA100	E. coli WP2
Negative Control	-		25	8	27	136	47
	+		17	8	41	154	44
Positive Control							
9-Aminoacridine	-	100		671			
2-Anthramine	+	2.5	179		1017	1211	
	+	10					542*
Creosote P1	-	5*	28	6	17	142	39
	-	10	32	6	28	132	39
	-	50	37	5	25	123	42
	-	100	34	7	18	137	34
	-	250*	29	4	16	75	39
	-	500	T	4	16	T	37
	-	1000*		T	10		26
	-	5000*			T		T
	+	5*	12	11	52	212	45
	+	10	20	14	60	215	49
	+	50	19	22	119	304	48
	+	100	17	30	125	330	40
	+	250*	26	52	149	441	47
	+	500	12	50	172	156	58
	+	1000*	T	31	214	T	44
	+	5000*		T	T		T

* Indicates the results of just one experiment. All other data are the average of two assays conducted on separate days.

T = Toxic

TABLE 21
(continued)

IN VITRO ASSAYS SALMONELLA TYPHIMURIUM AND ESCHERICHIA COLI
(Simmon and Poole, 1978)

Sample	Metabolic Activation	Amount of Sample Added Per Plate (ug)	Average Number of Revertants Per Plate: S. typhimurium TA1535	TA1537	TA98	TA100	E. coli WP2
Coal tar-Creosote P2, Class C	-	5*	31	4	31	106	37
	-	10	22	6	23	128	35
	-	50	28	3	23	119	45
	-	100	28	7	17	122	40
	-	250	21	6	15	70	43
	-	500	21	3	15	55	40
	-	1000	11	4	14	T	27
	-	5000	T	T	T		T
	+	5*	10	11	43	185	55
	+	10	16	23	62	186	61
	+	50	19	26	95	293	62
	+	100	20	37	147	347	49
	+	250	16	41	183	65	72
	+	500	15	58	163	196	59
	+	1000	8	40	145	T	49
	+	5000	T	T	T		T

* Indicates the results of just one experiment. All other data are the average of two assays conducted on separate days.

T = Toxic

P1 and P2 mixtures were dissolved in dimethylsulfoxide (DMSO) and were added to the cell cultures in varying test concentrations. A solvent control using 1% DMSO and a positive control using either dimethylnitrosamine (DMN) (in the presence of metabolic activation) or ethyl methanesulfonate (EMS) (in the absence of metabolic activation) were also tested. The cells were plated (duplicates of each exposure concentration, the solvent control, and the positive control were run) on a selective medium containing trifluorothymidine. The mutated cells grew on the medium; the cells which had not mutated did not grow.

Mutation frequency was calculated as the ratio of the number of mutant cells to surviving cells at each concentration of test chemical. The mean mutation frequency of the negative control samples was subtracted from the mutation frequency of each treated sample to give induced mutation frequencies. A relative total growth was determined for the controls and for each test concentration. The relative total growth is an expression of cell growth in relation to the negative control and is expressed as a percentage (Tables 22 through 25).

Creosote P1 and coal tar-creosote P2 had similar but not identical effects on the forward mutation frequency at the TK locus of L5178Y cells both with and without induced metabolic activation. In the presence of the Arochlor 1254-induced metabolic activation, a dose related increase in mutation frequencies above the spontaneous frequency was established for both P1 and P2. For P1 without metabolic activation, the only concentration that yielded a mutation frequency significantly above the spontaneous frequency was 0.96×10^{-2}. However, the relative total

TABLE 22

MOUSE LYMPHOMA FORWARD MUTATION ASSAY OF CREOSOTE P1 IN THE ABSENCE OF INDUCED METABOLIC ACTIVATION (Mitchell and Tajiri, 1978)

Concentration (percent v:v)	Relative Total Growth (%)	Calculated Mutation Frequency ($\times 10^{6}$)	Induced Mutation Frequency ($\times 10^{6}$)
Solvent Control (1% DMSO)	108.4 90.2	40 66	— —
Positive Control (500 ug/ml EMS)	37.2 52.1	573 663	520 610
0.980×10^{-2}	0.16 0.03	286 422	233 417
0.686×10^{-2}	36.8 40.3	57 82	4 29
0.480×10^{-2}	71.4 55.3	60 55	7 2
0.336×10^{-2}	78.3 76.9	79 77	26 24
0.235×10^{-2}	68.2 —	47 —	0 —
0.165×10^{-2}	68.3 79.6	71 75	18 22
0.115×10^{-2}	138.9 94.1	54 62	1 9
0.081×10^{-2}	85.1 71.9	68 56	15 3

TABLE 23

MOUSE LYMPHOMA FORWARD MUTATION ASSAY OF CREOSOTE P1 IN THE PRESENCE OF INDUCED METABOLIC ACTIVATION 1/ (Mitchell and Tajiri, 1978)

Concentration (percent v:v)	Relative Total Growth (%)	Calculated Mutation Frequency ($\times 10^{6}$)	Induced Mutation Frequency ($\times 10^{6}$)
Solvent Control (1% DMSO)	97.4 102.6	101 94	— —
Positive Control (100 ug/ml DMN)	6.3 10.8	445 282	347 184
3.00×10^{-3}	0.8 1.0	459 398	361 301
2.40×10^{-3}	3.9 4.4	318 305	221 207
1.92×10^{-3}	9.9 12.9	213 222	115 124
1.54×10^{-3}	23.0 21.3	167 185	70 87
1.23×10^{-3}	36.7 43.3	180 140	82 42
0.98×10^{-3}	42.8 43.1	169 174	71 76
0.79×10^{-3}	62.7 74.5	151 141	53 43
0.63×10^{-3}	84.3 77.9	120 128	23 30

1/ Arochlor 1254-induced rat liver S-9, batch IR-11.

TABLE 24

MOUSE LYMPHOMA FORWARD MUTATION ASSAY OF COAL TAR-CREOSOTE P2 IN THE ABSENCE OF INDUCED METABOLIC ACTIVATION (Mitchell and Tajiri, 1978)

Concentration (percent v:v)	Relative Total Growth (%)	Calculated Mutation Frequency ($\times 10^{6}$)	Induced Mutation Frequency ($\times 10^{6}$)
Solvent Control (1% DMSO)	108.4	40	—
	90.2	66	—
Positive Control (500 ug/ml EMS)	37.2	573	233
	52.1	663	417
0.980×10^{-2}	0.02	233	227
	0.01	—	—
0.686×10^{-2}	41.6	143	90
	32.9	176	123
0.480×10^{-2}	57.7	87	34
	63.2	79	26
0.336×10^{-2}	75.9	—	—
	70.7	65	12
0.235×10^{-2}	85.5	58	5
	—	—	—
0.165×10^{-2}	—	—	—
	60.3	93	40
0.115×10^{-2}	65.7	59	6
	67.5	61	8
0.081×10^{-2}	55.4	74	21
	66.8	52	0

(83)

TABLE 25

MOUSE LYMPHOMA FORWARD MUTATION ASSAY OF COAL TAR-CREOSOTE P2 IN THE PRESENCE OF INDUCED METABOLIC ACTIVATION 1/ (Mitchell and Tajiri, 1978)

Concentration (percent v:v)	Relative Total Growth (%)	Calculated Mutation Frequency ($\times 10^{6}$)	Induced Mutation Frequency ($\times 10^{6}$)
Solvent Control (1% DMSO)	97.4	101	—
	102.6	94	—
Positive Control (100 ug/ml DMN)	6.3	445	347
	10.8	282	184
3.00×10^{-3}	2.8	386	289
	1.9	370	273
2.40×10^{-3}	7.0	269	172
	5.8	338	240
1.92×10^{-3}	14.4	204	106
	16.1	236	139
1.54×10^{-3}	35.0	134	37
	36.7	190	92
1.23×10^{-3}	35.0	140	43
	36.3	147	49
0.98×10^{-3}	50.7	177	80
	56.9	152	55
0.79×10^{-3}	58.9	153	56
	77.8	117	20
0.63×10^{-3}	73.7	123	26
	75.9	121	23

1/ Arochlor 1254-induced rat liver S-9, batch IR-11.

(84)

growth was below 1%. For coal tar-creosote P2 without metabolic activation, two concentrations, 0.98×10^{-2} % and 0.686×10^{-2} %, yielded a mutation frequency significantly above the spontaneous frequency. Again, the relative total growth value at 0.98×10^{-2} % was below 1% survival. At 0.686×10^{-2} % the relative total growth value was approximately 35%.

3. Conclusion

Simmon and Poole (1978) found that following metabolic activation by Arochlor 1254-stimulated rat liver homogenate both the creosote P1 and the coal tar-creosote P2, Class C, produced a mutagenic dose-response and a doubling above background mutation rate with Salmonella typhimurium strains TA 1537, TA 98, and TA 100. Mitchell and Tajiri (1978) found that, following metabolic activation by Arochlor 1254-stimulated rat liver homogenate, creosote P1 and coal tar-creosote P2, Class C, increased the number of forward mutations at the thymidine kinase locus of L5178Y mouse lymphoma cells in a dose-related manner. The Working Group concluded that P1 and P2, Class C, caused mutations in Salmonella typhimurium strains TA 1537, TA 98, and TA 100, and in L5178Y mouse lymphoma cells. The Working Group, therefore, concluded that P1 and P2 are mutagenic in a multitest system and exceed the criteria of 40 CFR 162.11(a)(3)(ii)(A). Accordingly, the Agency is issuing a rebuttable presumption against creosote and coal tar-creosote mixtures.

C. Exposure

Although 40 CFR 162.11(a)(3)(ii)(A) does not require that exposure be demonstrated in order to presume against a pesticide on the basis of oncogenicity or on the basis of mutagenicity in a multitest system, a discussion of exposure to coal tar, creosote, and coal tar neutral oil is included for comment by interested persons. The Working Group considered three areas of exposure to these substances - industrial wood treatment, food residue, and user exposure.

1. Industrial Wood Treatment

a. General

The most important minor method of application is thermal treatment in which wood is immersed in open troughs filled with hot creosote followed by introduction of relatively cold creosote. The Working Group is not aware of any information on exposure to creosote from thermal treatment. The application of over 96% of all coal tar-creosote mixtures for wood preservation is by pressure treatment (American Wood Preservers' Institute, 1977).

The pressure treatment system is a closed system, and there is no need for direct worker contact with the liquid creosote or coal tar prior to its impregnation into the wood. The material arrives by truck or rail and is pumped into a holding tank where it is weighed. If the material is a creosote/coal tar solution of particular trade specifications, the solution is premixed at the production facility so that no mixing or manual transfer operations are required at the treatment plant. The treatment itself involves pressurization in airtight chambers. No workers are likely to be exposed from the treatment cylinders during the actual treatment process, nor are workers other than treating room operators required to be in the immediate vicinity of the chambers at this time. The treatment operator is responsible for the metering and introduction of coal tar/creosote into the cylinders. This func-

tion is performed in a control house near the chambers. In older facilities leakage of coal tar and creosote from old pipes and fittings may result in relatively high inhalation exposure to the treatment operators. Treatment time varies but ranges from about six to seven hours for each change of material. Following treatment, a vacuum is generally applied to withdraw excess preservative. After the excess is withdrawn, the chamber door is cracked open by a doorman. While still under vacuum, prior to withdrawal of the tram cars holding the treated wood, the door remains cracked open for approximately 15 minutes. The greatest opportunity for inhalation exposure appears to occur during the mechanical withdrawal of the tram cars from the pressure chamber. The wood-laden tram cars are linked to an engine and withdrawn to a storage area where the wood remains until shipment to the buyer.

Coal tar and creosote drippage occurs along the rail tracks leading from the chamber. This drippage is collected in ditches alongside the tracks and is pumped to a collecting pond along with creosote that has dripped from the pressure chambers at the time the charge was removed. Dike systems are employed around wood treatment plants to prevent runoff of creosote from the plant area. In at least one case, however, creosote was found to migrate from a treatment plant into the ground water supply of a neighboring community. The plant has since been shut down (Mittelman, 1978).

Non-routine operations such as cleaning of the treatment chamber may occur several times yearly. Workers in such operations are provided with suitable respirators and protective clothing.

b. Inhalation Exposure

On February 24-25, 1976, representatives of the National Institute of Occupational Safety and Health (NIOSH) [U.S. Department of Health, Education, and Welfare (USDHEW), 1977] and of Koppers Company (Smith, 1977) performed two separate air monitoring surveys at a Koppers Company wood preservation plant in Little Rock, Arkansas. Air samples were collected using lapel sampling pumps and analyzed for polycylic particulate organic matter (PPCM) by the NIOSH gravimetric method (NIOSH, 1977). The results of the two studies are presented in Table 26 and Table 27. 1/

Koppers Company also performed an air monitoring survey in July, 1977 (Webb, 1977) at the same Little Rock, Arkansas plant sampled by Koppers

1/ The lapel air sampling pumps collected the PPCM on a silver membrane-glass fiber filter which was held in place by a cellulose pad. Following collection of the air sample, NIOSH (USDHEW, 1977) desorbed the filter and the cellulose pad with cychlohexane. By contrast, Koppers (Williams, 1977) (Table 27) desorbed the filters, but not the cellulose pads, with benzene. The cyclohexane solution, or the benzene solution in the case of the Koppers' analyses, was placed in a teflon cup and the benzene or the cyclohexane was evaporated by placing the cup in a vacuum oven for three hours at 40°C. The weight of the remaining material was the cyclohexane or benzene soluble material. The concentration of mg/m^3 was determined by dividing the weight of the cyclohexane or benzene soluble material by the volume of air sampled. The results of the NIOSH analysis were generally higher than those of Koppers'. NIOSH, however, as stated above, desorbed the cellulose pad as well as the filter with cyclohexane, while Koppers desolved only the filter. Analysis of two blank cellulose pads for PPCM by NIOSH produced results of 115 and 120 ug/filter. No adjustment in the NIOSH report was made for the blank cellulose pads. To adjust for the blank samples, 117.5 ug/filter (the average of 115 and 120 ug/filter) was subtracted from the ug/filter reported for the NIOSH test samples by an EPA chemist for the purpose of presenting the table of results in this document. Where no results are reported for the "ug/filter" in Table 28, the ug/filter of the blank sample was higher than the test sample.

TABLE 26

RESULTS OF 1976 NIOSH MONITORING STUDY AT KOPPERS COMPANY WOOD TREATMENT PLANT IN LITTLE ROCK, ARKANSAS (U.S. Department of Health, Education, and Welfare, 1977)

Description (Date)	ug/filter 1/	Air Volume Sampled (m^3)	Concentration In Air (mg/m^3) 2/	Code of Worker or Site 3/
Treating Operator (2/24)	32.5	0.49	0.07	SM-6
Doorman (2/24)	-	0.53	-	SM-7
Treating Operator (2/25)	62.5	0.49	0.13	SM-11
Doorman (2/25)	-	0.51	-	SM-12
Locomotive Operator (2/24)	12.5	0.49	0.03	SM-8
Locomotive Operator (2/25)	52.5	0.56	0.09	SM-15
Locomotive Switchman (2/24)	-	0.73	-	SM-9
Locomotive Switchman (2/24)	-	0.57	-	SM-10
Locomotive Switchman (2/25)	137.5	0.50	0.28	SM-13
Locomotive Switchman (2/25)	42.5	0.50	0.08	SM-14
Treating Area 4/	52.5	0.44	0.12	SM-16

1/ This is the total amount measured on the filters minus the amount measured on the cellulose control blank.
2/ This is the concentration in the air of cyclohexane soluble polycylic particulate organic material.
3/ This code was given to each worker or site sampled. The same codes were used by Koppers Company in their sampling. See Table 27 for a comparison of the results.
4/ This is a stationary area sample. The other samples were collected from label sampling pumps.

TABLE 27

RESULTS OF 1976 KOPPERS' MONITORING STUDY AT KOPPERS COMPANY WOOD TREATMENT PLANT IN LITTLE ROCK, ARKANSAS (Smith, 1977)

Description (Date)	Concentration In Air (mg/m3) 1/	Code of Worker or Site
Treating Operator (2/24)	0.10	SM-6
Locomotive Switchman (2/24)	0.07	SM-9
Locomotive Switchman (2/24)	0.07	SM-10
Locomotive Switchman (2/25)	0.07	SM-15

1/ This is the concentration in the air of benzene soluble polycyclic particulate organic material.

TABLE 28

RESULTS OF 1977 KOPPERS COMPANY MONITORING STUDY AT LITTLE ROCK, ARKANSAS (Webb, 1977) 1/

Description	Concentration In Air (mg/m^3) 2/
Doorman	0.02
Doorman	0.07 3/
Treating Operator	0.05
Treating Operator	0.01
Switchman	0.03
Switchman	0.02
Switchman	< 0.01
Locomotive Operator	0.05
Locomotive Operator	0.01
Boring Operation	0.04
Area Clean Up	0.02

1/ The weather conditions during the study were the following: temperature, 72-83°F; relative humidity, 74-91%; barometric pressure, 30.00 inches Hg; and winds from the north at 5 mph.
2/ This is the concentration in the air of benzene soluble material.
3/ This doorman's exposure may have been higher because of his recovering a tram inside the cylinder following a break of the tram tow cable.

Company and NIOSH in July 1976 and using the NIOSH gravimetric technique used in the first Koppers' study. The results of the 1977 study are reported in Table 28.

The 1976 and 1977 Koppers' studies found a range of < 0.01 to 0.10 mg/m^3 benzene soluble material concentration in the air around the Little Rock wood treatment plant. The 1976 NIOSH study found a range of 0.03 to 0.26 mg/m^3 cyclohexane soluble material in the air around the Little Rock plant. No correlation appears to be evident between the type of work performed (e.g. treating operator, locomotive switchman, doorman, etc.) and the amount of air exposure.

There are several limitations to the method of collection employed by NIOSH. As stated, the method of analysis used is a gravimetric method and measures only the benzene or cyclohexane soluble fraction of polycyclic particulate organic matter in air samples. Thus, vapor phase polynuclear aromatic (PNA) hydrocarbons would go uncollected. Also, the gravimetric method used has not been fully evaluated for precision or accuracy nor has the solvent system been properly assessed for extraction efficiency. Another limitation to this method of analysis is its nonspecificity, i.e., the organic material weighed may include innocuous as well as carcinogenic materials.

c. Dermal Exposure

Handling of the treated wood at a pressure treatment plant is performed either mechanically or with metal utensils so that direct dermal exposure is minimal. Some dermal exposure does occur, however, as evidenced by reports of skin sensitization and burns, conjunctivitis, and eye irritation of workers in pressure treatment plants (McMillan, 1976).

2. Residues in Food

Creosote, coal tar, and coal tar neutral oil are not applied to food crops. Some evidence exists, however, that creosote or creosote-coal tar mixtures may leach out of marine pilings and contaminate marine life in the near vicinity and that this marine life may be eaten by humans or move through the food chain.

Dunn and Stich (1975, 1976a, 1976b) monitored mussel benzo[a]-pyrene contamination, and Zitko (1975) monitored various aquatic fauna for pyrene equivalents. Dunn and Stich (1975) found that mussels taken from a relatively pollution-free location contained higher benzo[a]-pyrene levels (49 ± 5.8 ppb) when near creosoted pilings than when distant from the pilings (2.1 ± 0.3 ppb). Analyses for the B[a]P was perperformed by thin layer chromatography (TLC) and fluorescent emission spectra. While TLC techniques have, for the most part, been superseded by high pressure liquid chromatography (hPLC) and gas chromatography (GC) methods offering greater separation from potential interferences and greater sensitivity, the data generated is valid and deserves greater investigation. Although it was not conclusively demonstrated that creosote was the source of the B[a]P contamination, it is not unlikely that creosote constituents may migrate from wood over time if only by purely mechanical means such as abrasion or swelling of the wood. The extent of this migration is unknown, but the data provided by Dunn and Stich (1975) must be considered in the absence of better-developed data.

The Working Group concluded that the extent of potential dietary exposure due to shellfish is unknown, but is likely to be small. A

total of 3.73 g/day of fresh, frozen, and canned shellfish was consumed per capita in the United States in 1974 (USDA, 1974). If it is assumed that shellfish taken from sites near creosoted pilings contain approximately 50 ppb B[a]P (i.e. 50 ug/kg) (Dunn and Stich, 1975), then the maximum daily intake of B[a]P would be 50 ug/kg x 3.73 g = 0.19 ug/person/day B[a]P. This exposure would result only if all shellfish contained the B[a]P content detected by Dunn and Stich, an assumption without supporting data, and also assuming the data of Dunn and Stich is representative of all shellfish near creosoted pilings.

3. User Exposure

a. Use of Treated Wood

Schwartz (1942) reported that workers exposed to creosoted floors developed erythematous, papular, and vesicular eruptions on their ankles one to two weeks after beginning work. The Pesticide Episode Reporting System (PERS) (1976) reported a number of incidents in which workers handling creosote-treated wood suffered adverse effects from exposure to the creosote (Appendix C).

The Working Group concluded that exposure from the handling of treated wood by workers such as railroad workers, utility pole workers, and workers installing pilings deserved greater attention. When this work is done in the summer, workers would probably incur the greatest potential exposure because of the inconvenience and discomfort of wearing protective clothing during this time of year.

b. Manual Application of Coal Tar, Creosote, and Coal Tar Neutral Oil for Wood Preservation

Birdwood (1938) reported on the permanent damage to vision of two gardeners who had gotten creosote in their eyes while treating fences. Jonas (1943) reported that Navy construction workers developed skin and eye irritation as a result of exposure to creosote while applying the creosote during construction. The Pesticide Episode Reporting System (1976) reported a number of incidents in which workers applying creosote suffered adverse effects from exposure (Appendix D).

The Working Group concluded that applicators who manually apply creosote are exposed, but no information is available to quantify this exposure.

c. Application of Creosote as an Herbicide

The Pesticide Episode Reporting System reported two cases of burns to applicators applying creosote as an herbicide (Appendix E).

The Working Group concluded that exposure to creosote does result from its application as an herbicide. The Working Group, however, is not aware of any information that is available to quantify this exposure.

d. Other Uses

Coal tar neutral oil and creosote are active ingredients of two insecticides used on horse and mule wounds (2 registrations). Coal tar neutral oil and creosote are both active ingredients of disinfectants for water closets, outhouses, garbage cans, animal areas, institutional premises, and sickroom areas (approximately 57 registrations). Coal tar and coal tar neutral oil are active ingredients in pesticide dips and shampoos for dogs (approximately 7 registrations). Creosote is an active

ingredient of a pesticide registered for mite and tick control in poultry houses. Coal tar neutral oil is an active ingredient of a pesticide registered for use on hog houses, sheep barns, dog kennels, and horse stables (6 registrations).

Creosote is an active ingredient in registrations for horse repellent (1 registration), a tree and shrub dressing (3 registrations), and an herbicide (2 registrations). Coal tar is an active ingredient in a crow repellent for seed corn (1 registration) and a human insect repellent (1 registration). Coal tar neutral oil is an active ingredient of approximately 16 mosquito larvicide registrations and 2 gypsy moth larvicide registrations.

No information is available regarding the potential exposure during application for the above uses. The uses involving coal tar and its derivatives in animal dips, washes or shampoos and the use of coal tar as a human insect repellent appear most likely to result in direct human contact.

III. OTHER ADVERSE EFFECTS

A. General

The information in this section relates to other adverse effects of creosote. The Working Group has concluded that the presently available information does not require issuance of a rebuttable presumption against registration on these effects. The Agency does solicit information on these problems, however, and requests that studies be conducted where necessary.

B. Skin and Eye Irritation

The Working Group reviewed several reports indicating that creosote is a potent skin and eye irritant.

Birdwood (1938) reported on two gardeners who got creosote into their eyes while creosoting fences. The two patients both complained of blurred vision and upon examination were found to have maculae upon the cornea and keratitis of the cornea. Birdwood reported that for both patients the impairment of vision would be permanent.

As indicated previously, the Pesticide Episode Reporting System (1976) reported 33 cases of eye damage, burns, or dermatitis resulting from creosote exposure either from treated wood or by application during the period August 1968 to April 1976 (Appendices C,D, and E).

McMillan (1976) reported on the accident history of 50 of the approximately 175 pressure-treating plants in the United States and Canada which use creosote to treat wood. About 3,000 employees out of approximately 7,000 employed in the industry were surveyed. Of those surveyed, 230 were reported to be directly exposed to creosote and fifteen hundred employees were reported to be either directly or indirectly exposed. The report was vague on the period of time which the survey covered. One employer reported for a 6-year period (1969-1975), one employer reported for a 10-year period (1961-1971), and 5 employers' reports were termed "historical." The time period covered for the other 43 plants was not reported. Also vague in the report was the number of treatment plants which documented or did not document the accident history. Of those which were documented, 98 cases of chemical conjunctivitis and 19 cases of eye irritation were reported. At least one treatment plant reported that eye irritation was "occasional." Sixty cases of skin burns and two allergic reactions were reported. At least one plant reported that skin burns were "infrequent."

Pfitzer et al. (1965) found that the instillation of 0.1 milliliter of creosote into the eyes of rabbits caused the conjunctiva to become slightly erythematous. Examination of the exposed eyes 24 hours following exposure showed that slight redness of the conjunctiva persisted in two of the eyes tested and the remaining four exposed eyes were essentially free of irritation. All of the exposed eyes were free of any apparent effects after seven days. Pfitzer et al. (1965) also reported that the contact of creosote with the intact and abraded areas of the skin of the bellies of rabbits for a maximum period of 24 hours produced moderate erythema and moderate to severe edema. The skin reactions remained relatively unchanged 72 hours following exposure. After 14 days, the exposed areas revealed severe epidermal flaking.

Schwartz (1942) reported that workers exposed to creosote treated floors developed erythematous, papular, and vesicular eruptions on their uncovered ankles one to two weeks after beginning work.

Jonas (1943) treated 450 Navy construction workers (1/6 of the workers at a Navy camp) for creosote burns. He found that fair-skinned, light-haired workers were particularly affected by creosote burns and that the number of burns increased on sunny days. Seventy percent of the burns were mild, while 30% were more severe and characterized by intense burning, itching, and considerable subsequent pigmentation followed by

desquamation. Fifteen percent of the 450 patients had inflammation of the conjunctiva, with mild cases being characterized by hyperennia of the mucus membranes and more severe forms by photophobia and a large amount of serous secretion. Three percent had injuries to the cornea varying from small abrasions to multiple large ones. One-third of these cases developed permanent corneal scars leaving hazy vision. These injuries were caused by flying chips of creosoted wood.

C. Toxicity to Livestock

The Working Group reviewed several reports indicating that creosote may have been responsible for toxic effects and death in some livestock.

1. Hanlon

Hanlon (1938) reported the loss of four steers and two cows from a lot of 94 head of cattle from what appeared to be creosote poisoning. The cattle were believed to have licked electric light poles which had recently been creosoted. Symptoms in affected animals consisted of extremely rapid respiration and evidence of burning over the mucosa of the mouth, tongue and lips, which were white and hardened. The pupils were contracted, the skin was cold, and the animals were in a comatose condition. Feces were black in color and the affected animals were apparently in agony. In the early stages they were reported to have evinced great thirst. A steer *in extremis* was killed, and an autopsy carried out immediately. Intense inflammation and congestion was evident in the whole gastrointestinal tract.

2. Lander

Lander (1926) (cited in Hanlon, 1930 and Harrison, 1959) reported the death of stock that had access to freshly treated railway ties. He stated that water may dissolve sufficient cresols from creosote-treated sleeper ties to cause livestock poisoning.

3. Wanntorp

Wanntorp (1953) (cited in Harrison, 1959) described several cases in which calves and cows died or had to be slaughtered after licking creosoted wood or poles. He mentions also the possibility that losses of poultry following the treatment of fowl houses with carbolineum (a high boiling point tar oil) may have been due to poisoning by tar derivatives.

4. Luke

Luke (1954) reported the death of four pigs, the suspected cause of which was the ingestion of coal tar pitch from the floor of their pen. The floor was made of old railway ties leveled off with pitch. Prior to death, the appetite of the pigs was very poor and coughing was widespread. Postmortem examination of the pigs found marked enlargement of the liver and several other liver anomalies in all four cases. Also, the abdominal cavities contained varying quantities of bloodstained fluid, and there was an excess of straw colored fluid in the pleural cavities. A pyogenic pneumonia was found in two carcasses, and in one of these there was a well-marked pericarditis. The lungs were normal in two cases and in one of these a marked cystic condition of the kidneys was found. *C. pyogenes* was isolated from the pneumonic lungs but cultures from liver, spleen, and heart blood were uniformly negative. From their findings, the authors concluded that pneumonia was not the principal cause of death, but that the death resulted from the liver damage. To test this hypothesis, the pitch was fed to two

groups of healthy pigs. Group A was comprised of three healthy pigs, each about 60 pounds in weight, and Group B of two pigs, each about 40 pounds in weight. The pigs in Group B were not thriving quite as well as those in Group A. A quantity of pitch was ground up and a small quantity added daily to the food for both groups. Over a period of 28 days, Group A received a quantity of two pounds of pitch. The pigs in Group B received four ounces of pitch over a period of 12 days. In both groups the addition of the pitch affected appetite and the pigs tended to be constipated. At the end of feeding for both groups, the pigs were killed and examined. In all three cases from Group A the pigs showed an enlargement of the liver together with a degree of liver damage similar to those of the original cases. Extensive liver lesions and a marked excess of peritoneal fluid were found in the pigs of Group B. Histological examination of the affected liver tissue from both field and experimental animals showed similar changes, viz. a marked central necrosis of the lobules which in some cases had completly destroyed the normal liver cell.

5. Harrison

Harrison (1959) determined from his experimental data that a 30 kg sheep would have to ingest 300 g of wood or 120 g of creosote to receive an acutely fatal dose; a 100 kg calf would have to ingest 1,000 g of wood or 400 g of creosote for the dose to be acutely fatal. These acute lethal doses are not LD 50 values, however. A chronic fatal dose for sheep would be 37.5 g of wood or 15 g of creosote ingested per day over a 1 month period; a chronic fatal dose for calves would be 125 g or 50 g of creosote per day for at least 11 days. Harrison thought that

the only danger to stock would be through their access to the raw preserving fluid either near stacks of freshly impregnated timber or on freshly treated farm timber and nearby contaminated vegetation.

6. Olafson and Leutritz

Olafson and Leutritz (1958) applied cresote to the skin of calves over the jaw area to preclude licking off the material. About three days after application, the skin developed slight swelling and became harder than normal. Gray creases appeared. From 7 to 10 days later, a dry crusty thickening of the skin had occurred. Healing took place slowly and recovery was not complete in four weeks.

Olafson and Leutritz (1958) also studied calf response following oral administration of creosote. They reported that a 1,000-pound cow would have to ingest over 75 cc of creosote before appreciable harm would result, although the exact basis for this determination was not stated.

D. Fetotoxicity

The Working Group identified one livestock study, the results of which may pose a question as to the fetotoxicity of creosote.

Schipper (1961) found a creosote-related fetotoxic effect with pregnant sows; the platforms of the cages in which the sows were housed had had three brush applications of a commercial creosote wood preservative. The sows were confined in the cages 2 and 10 days before giving birth. Twenty-four of the forty-one pigs delivered by the four sows were dead at birth. Of the remaining offsprings, six pigs died on day 1, four pigs on day 2, and one pig on day 3. The surviving pigs had rough skin, were dehydrated, and had severe diarrhea; weight gains were hindered until they were 5 and 6 weeks old. A control group was not included in the study, and the author did not report the route nor the amount of exposure.

Appendix A
SPECIFICATIONS FOR COAL-TAR CREOSOTE (NEW MATERIAL) (Fuller, 1977)

SPECIFICATION NUMBER	P1-65(1)	P13-65(2)	D390-67(3)	TT-C-645b(4) Class 1	Class 2	Class 3
Water (% by volume)	> 1.5	> 1.5	1.5 max	3.0 max	3.0 max	3.0 max
Matter insoluble in benzene (% by weight)	> 0.5	> 0.5	0.5 max	1.5 max	1.5 max	1.5 max
Specific gravity at 38° C compared to water at 15.5°C						
Original creosote	< 1.050	< 1.080	1.05 min	1.050 min	1.050 min	1.080 min
235-315°C fraction	< 1.027	< 1.030	0.027 min	1.027 min	1.027 min	1.030 min
315-355°C fraction	< 1.095	< 1.105	1.095 min	1.095 min	1.095 min	1.110 min
Residue above 355°C	—	< 1.160	—	—	—	1.160 min
Distillation						
To 210°C	> 2.0	> 2.0	2.0 max	2.0 max	2.0 max	2.0 max
To 235°C	>12.0	>12.0	12.0 max	12.0 max	12.0 max	12.0 max
To 270°C	<20.0;>40.0	20.0;>40.0	20.0-40.0	20-40	20-40	20-40
To 315°C	<45.0;>65.0	45.0;>65.0	45.0-65.0	45-65	40-65	45-65
To 355°C	<65.0;>82.0	65.0;>75.0	65.0-82.0	75-82	65-82	65-75
Service	Land. fresh water	Marine	Land. fresh water	Poles	General. land. fresh water	Marine

(1) For land and fresh water use. AWPA Std.
(2) For marine (coastal water) uses. AWPA Std.
(3) For land and fresh water use. ASTM Std.
(4) GSA standards for creosote in use

Appendix B
AWPA SPECIFICATIONS OF CREOSOTE-COAL TAR SOLUTIONS (NEW MATERIAL)
(Fuller, 1977)

REFERENCE	AWPA P2-68 GRADE A	B	C	D	P12-68(1)
Composition					
Creosote	<80	<70	<60	<50	—
Coal Tar	—	—	—	—	—
Water (% by volume)	> 3.0	> 3.0	> 3.0	> 3.0	3.0
Benzene, insol. (% by weight)	> 2.0	> 3.0	> 3.5	> 4.0	1.0-3.0
Coke residue (% by weight)	> 5.0	> 7.0	> 9.0	>11.0	4.0-7.0
Specific Gravity (38/15.5)					
Whole oil	1.06-1.11	1.07-1.12	1.08-1.13	1.09-1.14	1.090
235-315°C fraction	1.025	1.025	1.025	1.025	1.030
315-355°C fraction	1.085	1.085	1.085	1.085	1.105
Residue	—	—	—	—	1.185
Distillation					
To 210°C	5	5	5	5	5.0
To 235°C	25	25	25	25	15.0
To 270°C	—	—	—	—	20-35
To 315°C	36	34	32	30	35-50
To 355°C	60	56	52	48	55-70
Residue	—	—	—	—	—

(1) For use in treatment of marine piles and timbers.
Source: Hartford (1973).

APPENDIX C Cops & Tm. Cops Ctr

REPORT OF EPISODES OF EXPOSURE TO CREOSOTE FROM TREATED LUMBER 1/
(Adapted from PLRS, 1976)

Date of Episode	State	Causative Agent Verification 2/	Remarks 3/
2/25/73	CA	Probable	A dockworker developed a rash on his arms after contacting crates coated with creosote.
4/5/73	CA	Probable	A carpenter sustained chemical burns on his face, hands and arms while painting fence posts with creosote.
4/12/73	CA	Yes	A carpenter was handling timbers at a shipyard. Creosote splashed into his left eye, which developed redness and pain.
4/26/73	CA	Probable	A welder developed a rash on his hips, chest, thighs and trunk while working around treated railroad ties.
6/1/73	CA	Probable	A maintenance man developed an erythematous rash, first degree burns and chemical irritation while handling freshly treated poles.
6/29/73	CA	Probable	A wood worker developed first degree chemical burns when he rubbed the chemical on his face while working.
7/9/73	CA	Probable	An equipment operator for a county water agency was removing poles treated with creosote all day. His face and neck became red, swollen and sore.
8/9/73	CA	Probable	A lineman was holding treated utility poles with gloves when he wiped his face, thereby transferring creosote from the gloves to his face. Diagnosed as chemical burn.

APPENDIX C
(continued)

REPORT OF EPISODES OF EXPOSURE TO CREOSOTE FROM TREATED LUMBER 1/
(Adapted from PERS, 1976)

Date of Episode	State	Causative Agent Verification 2/	Remarks 3/
9/20/73	CA	Probable	Laborer developed contact dermatitis on his buttocks while working with treated lumber.
1/75	CA	Yes	Laborer working with treated wood developed dermatitis on hands and arms.

1/ Records checked from 1967 through April, 1976.
2/ Verification indicates whether the pesticide associated with the episode was established as the causative agent which resulted in death, illness, etc. "Yes" indicates that substantial evidence exists linking the pesticide to the episode's effects; "Probable" indicates circumstantial evidence exists linking the pesticide to the episode's effects.
3/ In all cases 1 human received medical attention.

APPENDIX C (continued)

REPORT OF EPISODES OF EXPOSURE TO CREOSOTE FROM APPLICATION 1/
(Adapted from PERS, 1976)

Date of Episode	State	Causative Agent Verification 2/	Remarks 3/
2/23/72	CA	Probable	A carpenter developed sub-acute conjunctivitis after getting creosote in his eye at work.
3/72	CA	Probable	A carpenter sustained burns of the face, arms and hands when he came into contact with creosote spray.
10/2/72	CA	Probable	A construction worker developed a rash on all extremities while working with creosote.
4/23/73	CA	Probable	A construction worker developed chemical burns of both forearms while carrying creosote-treated wood.
4/26/73	CA	Probable	A laborer at a lumber yard sustained first degree burns on both arms while moving creosote from a tank.
6/6/73	CA	Probable	A laborer developed erythema of the face, neck and forearms when he inadvertently touched creosote on them.
6/11/73	CA	Probable	A carpenter splashed creosote into both eyes and developed chemical keratoconjunctivitis.
6/18/73	CA	Probable	A carpenter spilled creosote on arms and face and developed superficial irritation of arms and face.
6/27/73	CA	Probable	A student got creosote on forearms while painting posts and developed chemical burns.

APPENDIX D
(continued)

REPORT OF EPISODES OF EXPOSURE TO CREOSOTE FROM APPLICATION[1/]
(Adapted from PERS, 1976)

Date of Episode	State	Causative Agent Verification[2/]	Remarks[3/]
7/24/73	CA	Probable	A laborer developed first degree burns of the arms, face and hands after painting posts with creosote.
7/26/73	CA	Probable	A carpenter sustained first degree burns on his face, forearms and lower abdomen when he splashed the material on himself during an application operation.
7/31/73	CA	Probable	A laborer for a construction company sustained a chemical burn when the material was sprayed on his arms and face.
9/24/73	CA	Probable	A laborer got creosote in his face and eyes thereby sustaining a chemical burn.
8/24/74	NJ	Yes	A woman was injured when the can from which she was pouring creosote onto the foundation of her home, slipped from her hand, splashing the chemical on her legs and into her eyes.
4/25/75	CA	N/A	A man was applying creosote to a ramp when he accidentally splashed it on his face. The effect of the accident was not reported.
5/25/75	CA	Probable	An employee was treating a wooden block. Material splashed onto him, resulting in contact dermatitis.

1/ Records checked from 1967 through April, 1976.
2/ Verification indicates whether the pesticide associated with the episode was established as the causative agent which resulted in death, illness, etc. "Yes" indicates that substantial evidence exists linking the pesticide to the episode's effects; "Probable" indicates circumstantial evidence exists linking the pesticide to the episode's effects.
3/ In all cases 1 human received medical attention.

APPENDIX E

REPORT EPISODES OF BURNS SUFFERED FROM THE APPLICATION OF CREOSOTE AS AN HERBICIDE (Adapted from PERS, 1976)[1/]

Date of Episode	State	Causative Agent Verification[2/]	Remarks[3/]
4/21/73	CA	Probable	A pest control operator sustained chemical burns of the face while spraying weeds.
6/14/73	CA	Probable	A lumber company worker was spraying weeds. Wind blew the herbicide into his face and the worker sustained first degree burns.

1/ Records checked from 1967 through April, 1976.
2/ Verification indicates whether the pesticide associated with the episode was established as the causative agent which resulted in death, illness, etc. "Yes" indicates that substantial evidence exists linking the pesticide to the episode's effects; "Probable" indicates circumstantial evidence exists linking the pesticide to the episode's effects.
3/ In all cases 1 human received medical attention.

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**** PRODUCT SEARCH LISTING **** PAGE 1

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 000043 CABOT SAMUEL INC
CNE UNION ST
BOSTON MA 02108

********** PRODUCT NAME **********

**00003* CABOT'S CREOSOTE SHINGLE STAINS 345 SMOKE GRAY

**00004* CABOT'S CREOSOTE SHINGLE STAINS 247 DARK GRAY

**00005* CABOT'S CREOSOTE SHINGLE STAINS 238 DARK BUNGALOW BROWN

**00006* CABOT'S CREOSOTE SHINGLE STAINS 220 TILE RED

**00007* CABOT'S CREOSOTE SHINGLE STAINS 237 DARK BROWN

**00008* CABOT'S CREOSOTE SHINGLE STAINS 222 DARK BROWNISE RED

**00009* CABOT'S CREOSOTE SHINGLE STAINS 227 DARK RED

**00010* CABOT'S CREOSOTE SHINGLE STAINS 230 COLORLESS CREOSOTE

**00011* CABOT'S CREOSOTE SHINGLE STAINS 244 SILVER GRAY

**00012* CABOT'S CREOSOTE SHINGLE STAINS 270 DARK BLUE

**00013* CABOT'S CREOSOTE SHINGLE STAINS 239 SEAL BROWN

**00014* CABOT'S CREOSOTE SHINGLE STAINS 243 MEDIUM GRAY

**00015* CABOT'S CREOSOTE SHINGLE STAINS 258 SPRUCE GREEN

**00017* CABOT'S CREOSOTE STAINS MEDIUM MOSS GREEN 0255

**00018* CABOT'S CREOSOTE STAINS DARK MOSS GREEN 0252

**00019* CABOT'S CREOSOTE SHINGLE STAINS 260 BLACK

**00020* CABOT'S CREOSOTE SHINGLE STAINS 251 LIGHT MOSS GREEN

**00021* CABOT'S CREOSOTE SHINGLE STAINS 281 DARK WEATHER BROWN

**00022* CABOT'S CREOSOTE SHINGLE STAINS 280 LIGHT WEATHER BROWN

**00026* CABOT'S CREOSOTE STAINS 250 EUCALYPTUS GREEN

**** PRODUCT SEARCH LISTING **** PAGE 2

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

**CONTINUE REGISTRANT 000043

**00031* CABOT'S NO. 3600 CREOSOTE OIL

**00032* CABOT'S NO. 3770 CREOSOTE OIL

**00033* CABOT'S CREOSOTE STAINS 0233 RED CEDAR

**00035* CABOT'S WOOD PRESERVING CREOSOTE SHINGLE STAINS 231 PUMPKIN YELLOW

**00036* CABOT'S CREOSOTE STAINS 0246 SAGEBRUSH GRAY

**00037* CABOT'S CREOSOTE STAINS 0249 CHARCOAL

**00039* CABOT'S CALIFORNIA REDWOOD STAIN #325

**00057* CABOT S CREOSOTE STAINS 0211 WHITE

**00058* CABOT'S GYPSY MOTH CRESOTE #3900

**00070* CABOT"S 0070 WHITE CREOSOTE PAINT

**00071* CABOT'S CONSERVO #3300

****

REGISTRANT *NAME AND ADDRESS*

* 000052 WEST CHEMICAL PROD INC
KATZ ALBERT MR 42-16 W ST
NEW YORK, NY 10001

********** PRODUCT NAME **********

**00023* WESCOI

**** PRODUCT SEARCH LISTING **** PAGE 3

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 000059 BURROUGHS WELLCOME COMPANY
BURROUGHS WELLCOME COMPANY
3030 CORNWALLIS ROAD
RESEARCH TRIANGLE PARK, NC 27709

********** PRODUCT NAME **********

**00005* COOPER FARM DISINFECTANT

****

REGISTRANT *NAME AND ADDRESS*

* 000061 KOPPERS COMPANY, INCORPORATED
GENERAL OFFICES-KOOPERS BLD
PITTSBURGH PA 15219

********** PRODUCT NAME **********

**00094* KOPPERS COAL TAR CREOSOTE

**00096* KOPPERS NOLINEUM

**00129* KOPPERS WOOD PRESERVATIVES SPECIAL OIL

**00130* KOPPERS WOOD PRESERVATIVES 50/50 CREOSOTE-COAL TAR SOLUTION

**00131* KOPPERS WOOD PRESERVATIVES 60/40 CREOSOTE-COAL TAR SOLUTION

**00132* KOPPERS WOOD PRESERVATIVES 80-20 CREOSOTE-COAL TAR SOLUTION

**00133* KOPPERS WOOD PRESERVATIVES 70/30 CREOSOTE-COAL TAR SOLUTION=

**** PRODUCT SEARCH LISTING **** PAGE 4

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 000134 HESS AND CLARK DIV OF RHODIA INC
ASHLAND OH 44805
ASHLAND, OH 44805

************ PRODUCT NAME **********

**00006* HESS & CLARK FARM & HOME DISINFECTANT

****

REGISTRANT *NAME AND ADDRESS*

* 000218 ALLIED CHEMICAL CORPORATION
P.O. BOX 1058-R
MORRISTOWN NJ 07960

************ PRODUCT NAME **********

**00132* CREOSOTE OIL 24 CB

**00136* CREOSOTE COAL TAR SOLUTION

**00137* REFINED CREOSOTE OIL (TANK TRUCK, CAR AND SHIP)

**00150* BARRETT CREOSOTE OIL-24-CA

**00609* CREOSOTE OIL

**00612* CRUDE COAL TAR

****

REGISTRANT *NAME AND ADDRESS*

* 000299 MARTIN C J COMPANY
606 W MAIN PO BOX 1089
NACOGDOCHES TX 75961

************ PRODUCT NAME **********

**** PRODUCT SEARCH LISTING **** PAGE 5

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

**CONTINUE REGISTRANT 000299

**00156* MARTIN'S M & S CREOSOTE OIL

**00162* CREOSOTE DIP

****

REGISTRANT *NAME AND ADDRESS*

* 000346 RUSSELL I D COMPANY LABS
PO BOX 1
KANSAS CITY MO 64141

********** PRODUCT NAME **********

**00006* RUSSELL'S REVENGE LITTER SPRAY

****

REGISTRANT *NAME AND ADDRESS*

* 000363 COOPERS CREEK CHEMICAL CORP
RIVER ROAD
WEST CONSHOHOCKEN, PA 19428

********** PRODUCT NAME **********

**00007* THE C-4 BRAND ZIP PHENOLIC DISINFECTANT

**00014* THE C-4 BRAND BLACK CREOSOTE COAL TAR SOLUTION

**00015* THE C-4 BRAND COPPERSOTE CREOSOTE OIL

**** PRODUCT SEARCH LISTING **** PAGE 6

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 000374 ELROY TURPENTINE COMPANY
BOX 688
SWAINSBORO GA 30401

********** PRODUCT NAME **********

**00007* ELROY CREOSOTE OIL (DARK)

****

REGISTRANT *NAME AND ADDRESS*

* 000419 CENCL COMPANY
DIV OF BURGESS VIBROCRAFTERS INC
P O BOX 177 ROUTE 45 & PETERSON RD
LIBERTYVILLE, IL 60048

********** PRODUCT NAME **********

**00121* CENOL PHENOLIC DISINFECTANT

****

REGISTRANT *NAME AND ADDRESS*

* 000421 VARLEY JAMES & SONS INC
1200 SWITZER AVE
ST LOUIS MO 63147

********** PRODUCT NAME **********

**00095* COAL TAR DISINFECTANT COEF. 6

**00096* COAL TAR DISINFECTANT AND STOCK DIP PHENOL COEF.7.5

**00099* COAL TAR DISINFECTANT PHENOL COAFFICIENT 5

**00100* COAL TAR DISINFECTANT PHENOL COEFFICIENT AT LEAST 10%

**00101* COAL TAR DISINFECTANT AND STOCK DIP

**** PRODUCT SEARCH LISTING **** PAGE 7

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

**CONTINUE REGISTRANT 000421

**00146* COAL TAR DISINFECTANT

**00149* MOSQUITO LARVAECIDE

**00399* CREOSOTE WOOD PRESERVING OIL

****

REGISTRANT *NAME AND ADDRESS*

* 000453 WOOD TREATING CHEMICALS DEPT
KOPPERS CO INC
DEPT. KOPPERS CO. 5137 SOUTHWEST AVE.
ST LOUIS MO 63110

********** PRODUCT NAME **********

**00089* POLE - TREAT PENETRATING PRESERVATIVE COATING

**00103* POLE-LIFE PRESERVATIVE PASTE T-E

**00158* C WOOD PRESERVATIVE AT-8242

**00171* POLE TREAT 15 PENETRATING PRESERVATIVE COATING

**00182* TRITOX PRESERVATIVE PASTE

**00259* POLE-LIFE PRESRVATIVE PASTE TE

****

REGISTRANT *NAME AND ADDRESS*

* 000458 STANDARD TAR PRODUCTS COMPANY
2456 W CORNELL ST
MILWAUKEE WI 53209

********** PRODUCT NAME **********

**00002* USOL CREOSOTE OIL

**00013* USOL CLEAR GRAIN NATURAL WOOD FINISH AND WOOD PRESERVATIVE

**** PRODUCT SEARCH LISTING **** PAGE 8

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

**CONTINUE REGISTRANT 000458

**00020* USOL CABIN OIL WITH PENTA

****

REGISTRANT *NAME AND ADDRESS*

* 000475 BOYLE-MIDWAY INC
S AVE & HALE ST
CRANFORD NJ 07016

********** PRODUCT NAME **********

**00018* SALEM WITCH BRAND CREOL DISINFECTANT

****

REGISTRANT *NAME AND ADDRESS*

* 000491 SELIG CHEMICAL INDUSTRIES THE
DIV NATIONAL SERVICE INDS INC PO BOX 43106
ATLANTA GA 30336

********** PRODUCT NAME **********

**00013* STEROLIN DISINFECTANT COEFF. 6

**00026* PIRATOL DISINFECTANT

**00027* SELIG,S LARVACIDE

****

REGISTRANT *NAME AND ADDRESS*

* 000528 AMSCO DIVISION UNION OIL COMPANY OF CALIFORNIA
825 SE THORNTON
MINNEAPOLIS MN 55414

********** PRODUCT NAME **********

**** PRODUCT SEARCH LISTING **** PAGE 9

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

**CONTINUE REGISTRANT 000528

**00029* AMSCO'S CREOSOTE WOOD PRESERVER

**00057* BARCOSOTE CREOSOTE PENTA WOOD PRESERVER

****

REGISTRANT *NAME AND ADDRESS*

* 000541 PURITAN CHEM COMPANY
PO BOX 93247 MARTECH STATION
ATLANTA GA 30318

********** PRODUCT NAME **********

**00045* PURI-LARV A MOSQUITO LARVICIDE

****

REGISTRANT *NAME AND ADDRESS*

* 000551 BAIRD & MCGUIRE INC
SOUTH ST
HOLBROOK MA 02343

********** PRODUCT NAME **********

**00006* COAL TAR DISINFECTANT DEODORANT-CLEANER

**00009* COAL TAR DISINFECTANT COEF. 5

**00011* COAL TAR DISINFECTANT COEF. 4

**00012* COAL TAR DISINFECTANT COEF. 3

**00013* COAL TAR DISINFECTANT COEF. 7

**00015* COAL TAR DISINFECTANT COEF. 8

**00016* COAL TAR DISINFECTANT COEF. 10

**00213* COAL TAR DISINFECTANT COEF. 6

**** PRODUCT SEARCH LISTING **** PAGE 10

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

**CONTINUE REGISTRANT 000551

**00218* CREOSOTE OIL

****

REGISTRANT *NAME AND ADDRESS*

* 000572 ROCKLAND CHEMICAL CO. INC.
P.O. BOX 809
CALDWELL, NJ 07006

********** PRODUCT NAME **********

**00096* ROCKLAND CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 000576 SUWANNEE DRUG COMPANY
PO BOX 128
NEWBERRY FL 32669

********** PRODUCT NAME **********

**00008* BARRY'S DERMA-SEAL SCREW WORM KILLER

****

REGISTRANT *NAME AND ADDRESS*

* 000603 CHEMTECH IND INC
3033 GLENFIELD, PO BOX 24440
DALLAS, TX 75224

********** PRODUCT NAME **********

**00016* DIXIE LARVACIDE

**** PRODUCT SEARCH LISTING **** PAGE 11

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 000619 HUGGINS JAMES & SON INC
239 MEDFORD ST
MALDEN MA 02148

********** PRODUCT NAME **********

**00008* (H) KOLTAROL DISINFECTANT PHENOL COEFFICIENT 2

**00012* KOLTAROL DISINFECTANT

**00025* DIAMOND E CREOSOTE PRESERVATIVE

**00030* S-P-F WOOD PRESERVER & INSECTICIDE

****

REGISTRANT *NAME AND ADDRESS*

* 000746 MFA OIL CO
P.O. BOX 519
COLUMBIA MO 65201

********** PRODUCT NAME **********

**00008* MFA GENERAL DISINFECTANT AND DEODORANT

****

REGISTRANT *NAME AND ADDRESS*

* 000912 FARMERS UNION CENTRAL EXCHANGE INC
POST OFFICE BOX "G"
ST PAUL MN 55164

********** PRODUCT NAME **********

**00028* CO-OP BARN & LIVESTOCK AREA DISINFECTANT

**** PRODUCT SEARCH LISTING **** PAGE 12

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COAL TAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 000928 CARBOLINEUM WOOD PRES COMPANY
ATTN LEYPOLDT F JR 6683 N 40TH ST
MILWAUKEE WI 53200

********** PRODUCT NAME **********

**00001* AVENARIUS CARBOLINEUM

****

REGISTRANT *NAME AND ADDRESS*

* 000931 KANSAS CITY VACCINE COMPANY
1611 GENESEE ST
KANSAS CITY MO 64102

********** PRODUCT NAME **********

**00008* FARMADE VET. PAINT

****

REGISTRANT *NAME AND ADDRESS*

* 000962 LOS ANGELES CHEMICAL COMPANY
4545 ARDINE ST
SOUTH GATE CA 90280

********** PRODUCT NAME **********

**00096* LACCO BRAND A.W.P.A. CREOSOTE

**** PRODUCT SEARCH LISTING **** PAGE 13

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 000984 WHITMOYER LAB INC
AFFILIATED LABORATORIES DIV.
1 GIBRALTAR PLAZA
HORSHAM, PA. 19044

********** PRODUCT NAME **********

**00041* BARKER'S DISINFECTANT

****

REGISTRANT *NAME AND ADDRESS*

* 001019 LEGEAR DIVISION
2150 METRO BLVD.
MARYLAND HEIGHTS, MO. 63043

********** PRODUCT NAME **********

**00059* LEGEAR MULTI PURPOSE DISINFECTANT

****

REGISTRANT *NAME AND ADDRESS*

* 001022 CHAPMAN CHEMICAL COMPANY
BOX 9158
MEMPHIS TN 38109

********** PRODUCT NAME **********

**00218* TIMPREG PAK

**00256* TIMPREG

**00379* TIMPREG E SPECIAL

**00408* CHAPMAN POL-NU 15-15 PENTA PRESERVATIVE GREASE WITH CREOSOTE ADDED

**00496* POL-NU 20-20

**** PRODUCT SEARCH LISTING **** PAGE 14

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COAL TAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 001127 BOURBON CO
BOX 466
LEXINGTON KY 40501

********** PRODUCT NAME **********

**00008* BOURBON DIP & DISINFECTANT CONC. 5

**00026* NO. 56 CREOSOTE OIL

****

REGISTRANT *NAME AND ADDRESS*

* 001136 NU BRITE CHEMICAL COMPANY
10 FIRST ST
TAUNTON MA 02780

********** PRODUCT NAME **********

**00011* NU BRITE CREOSOTE PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 001200 U.S. EAGLE, INC.
P.O. BOX 59031
DALLAS, TX 75229

********** PRODUCT NAME **********

**00006* EAGLE MOSQUITO LARVACIDE

**** PRODUCT SEARCH LISTING **** PAGE 15

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 001266 MALTER INTERNATIONAL CORPORATION
PO BOX 6099
NEW ORLEANS LA 70114

********** PRODUCT NAME **********

**00025* MALCO JET 99 MOSQUITO LARVACIDE

****

REGISTRANT *NAME AND ADDRESS*

* 001269 DEWITT CHEMICAL COMPANY
BOX 343
ATLANTA GA 30301

********** PRODUCT NAME **********

**00078* DEWITT GARBAGE TRUCK MAINTAINER

****

REGISTRANT *NAME AND ADDRESS*

* 001270 ZEP MANUF CORP
BOX 2015
ATLANTA GA 30301

********** PRODUCT NAME **********

**C0100* ZEP GARBAGE TRUCK MAINTAINER

**** PRODUCT SEARCH LISTING **** PAGE 16

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 001286 PARKE DAVIS & COMPANY
JOS CAMPAU AVE
DETROIT MI 48232

********** PRODUCT NAME **********

**00008* KRESO DIP NO. 1

****

REGISTRANT *NAME AND ADDRESS*

* 001381 LAND O'LAKES C/O IMPERIAL INC
PO BOX 423
SHENANDOAH IA 51601

********** PRODUCT NAME **********

**00074* FELCO 99 BUILDING DISINFECTANT

****

REGISTRANT *NAME AND ADDRESS*

* 001386 UNIVERSAL COOPERATIVES INC
3001 METRO DR. SUITE 500
MINNEAPOLIS MN 55420

********** PRODUCT NAME **********

**00044* STOCK PREMISES DISINFECTANT

**** PRODUCT SEARCH LISTING **** PAGE 17

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 001421 DETTELBACH CHEMICALS CORP
ATTN WARD A R 4161 PEACHTREE RD NE
ATLANTA GA 30319

********** PRODUCT NAME **********

**00036* BLACK DISINFECTANT CORP. 5

**00043* MOSQUITO-LARVACIDE

****

REGISTRANT *NAME AND ADDRESS*

* 001456 REILLY TAR & CHEMICAL CORP.
11 SOUTH MERIDIAN ST.
INDIANAPOLIS, IND 46204

********** PRODUCT NAME **********

**00018* REILLY CREOSOTE OIL

**00019* 50/50 CREOSOTE COAL TAR SOLUTION

**00020* 60/40 CREOSOTE COAL TAR SOLUTION

**00021* 80/20 CREOSOTE COAL TAR SOLUTION

**00022* 70/30 CREOSOTE COAL TAR SOLUTION

****

REGISTRANT *NAME AND ADDRESS*

* 001469 ANALAB LABORATORIES INC
285 WASHINGTON ST
SOMERVILLE MA 02143

********** PRODUCT NAME **********

**** PRODUCT SEARCH LISTING **** PAGE 18

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

**CONTINUE REGISTRANT 001469

**00009* COAL TAR DISINFECTANT COEF. 2

****

REGISTRANT *NAME AND ADDRESS*

* 001616 WARREN-DOUGLAS CHEMICAL COMPANY INC
3002 F ST
OMAHA NE 68107

********** PRODUCT NAME **********

**00041* WARLASCO...NC 1 REFINED WOOD PRESERVING OIL

****

REGISTRANT *NAME AND ADDRESS*

* 001686 GEORGIA-CAROLINA OIL COMPANY
1405 6TH ST PO BOX 4304
MACON GA 31200

********** PRODUCT NAME **********

**00008* REFINED CREOSOTE OIL COAL TAR CREOSOTE 96 1/2%

****

REGISTRANT *NAME AND ADDRESS*

* 001691 CHEMICAL COMPOUNDING CORP
680 ELTON AVENUE
RIVERHEAD, NY 11901

********** PRODUCT NAME **********

**00004* SUPERTOX 10

**00006* SUPERTOX

**** PRODUCT SEARCH LISTING **** PAGE 19

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

**CONTINUE REGISTRANT 001691

**00007* SUPERTOX

**00018* SUPERSAN SUPERTOX 3

**00101* QUIST SUPERTOX COEF. 6

**00103* QUIST SUPERTOX COEF. 2

****

REGISTRANT *NAME AND ADDRESS*

* 001719 MOBILE PAINT MANUFACTURING COMPANY INC
BOX 717-THEODORE INDS. PARK HAMILTON RD
THEODORE AL 36582

********** PRODUCT NAME **********

**00019* CREOSOTE NON-CRYSTALIZING 74-3

****

REGISTRANT *NAME AND ADDRESS*

* 001769 NATIONAL CHEMSEARCH DIV
USACHEM INC
2727 CHEMSEARCH BLVD
IRVING TX 75060

********** PRODUCT NAME **********

**00009* NATIONAL MOSQUITO LARVAECIDE

**** PRODUCT SEARCH LISTING **** PAGE 20

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 001783 TRIC CHEMICAL WORKS INC
341-347 SCHOLES ST
BROOKLYN NY 11200

********** PRODUCT NAME **********

**00009* AMAZON COAL TAR DISINFECTANT PHENOL COEF. 6

**00017* AMAZON COAL TAR DISINFECTANT COEF. 2

**00075* CREOSOTE OIL TECHNICAL WOOD PRESERVATIVE

**00076* AMAZON CREOSOTE OIL COMPOUND

****

REGISTRANT *NAME AND ADDRESS*

* 001786 USS CHEMICALS DIV US STEEL CORP
600 GRANT ST (RM. 2868)
PITTSBURGH, PA 15230

********** PRODUCT NAME **********

**00001* COAL TAR CREOSOTE OIL

**00002* 70-/30 CREOSOTE COAL TAR SOLUTION

**00003* 80/20 CREOSOTE COAL TAR SOLUTION

**00004* CRUDE COAL TAR

**00005* 60/40 CREOSOTE COAL TAR SOLUTION

**00006* 50/50 CREOSOTE COAL TAR SOLUTION

**** PRODUCT SEARCH LISTING **** PAGE 21

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 001926 NAVY BRAND MFG COMPANY
5111 SW AVE
ST LOUIS MO 63110

********** PRODUCT NAME **********

**00012* NAVY BRAND LM 120-LARVACIDE

**00069* LM 120 LARVACIDE

****

REGISTRANT *NAME AND ADDRESS*

* 001941 ELCO MANUFACTURING COMPANY
111 3RD ST SHARPSBURG
PITTSBURGH PA 15215

********** PRODUCT NAME **********

**00019* ELCO CREOSOTE WOOD PRESERVATIVE

**00031* ELCOCENE

**00038* ELCO CREOSOTE-OIL BLEND WOOD PRESERVATIVE

**00078* ELCRECI COAL DISINFECTANT

****

REGISTRANT *NAME AND ADDRESS*

* 002072 CONTINENTAL PRODUCTS COMPANY
1150 EAST 222 ST
EUCLIDE OH 44117

********** PRODUCT NAME **********

**00005* 75-904D CONTINENTAL CREOSOTE OIL

**** PRODUCT SEARCH LISTING **** PAGE 22

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 002077 BERNUTH LEMBCHE COMPANY INC
THE FIRST STATE BANK BLDG.
SUITE 609
MIAMI, FL 33138

********** PRODUCT NAME **********

**00001* B-L COAL TAR CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 002155 SCHNEIDI.INC.
1429 FAIRMONT AVE N W
ATLANTA GA 30318

********** PRODUCT NAME **********

**00006* BLACK DISINFECTANT PHENOL COEF. 5

**00007* , BLACK DISINFECTANT PHENOL COEF.3

**00008* BLACK DISINFECTANT PHENOL COEF. 2

****

REGISTRANT *NAME AND ADDRESS*

* 002192 RED SPOT PAINT & VARNISH COMPANY INC
110 MAIN ST
EVANSVILLE IN 47704

********** PRODUCT NAME **********

**00004* RED SPOT CREOSOTE OIL

**** PRODUCT SEARCH LISTING **** PAGE 23

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 002217 FBI-GORDON CORPORATION
300 SO 3RD ST
KANSAS CITY KS 66118

********** PRODUCT NAME **********

**00423* GORDON'S CREOSOTINE

****

REGISTRANT *NAME AND ADDRESS*

* 002270 HUGE COMPANY INC
7625 PAGE AVE
ST. LOUIS, MO 63133

********** PRODUCT NAME **********

**00168* EXCELCIDE MOSQUITO EGG AND LARVAE KILLER

****

REGISTRANT *NAME AND ADDRESS*

* 002279 SOUTHERN PROTECTIVE PROD CO
PO BOX 10915
ATLANTA GA 30310

********** PRODUCT NAME **********

**00004* SOUTHERN REFINED CRESOTE

**** PRODUCT SEARCH LISTING **** PAGE 24

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

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REGISTRANT *NAME AND ADDRESS*

* 002337 DEMERT & DOUGHERTY INC
AEROPAK DIVISION
333 SKOKIE BLVD
NORTHBROOK, IL 60062

********** PRODUCT NAME **********

**00002* DED TOXOIDUM CREOSOTE FOR DIPPING OR BRUSHING

**00065* D & D HIGHLY REFINED NO. 1 CREOSOTE OIL

****

REGISTRANT *NAME AND ADDRESS*

* 002413 M & M CHEMICAL SALES CORP
1073 HANCOCK STREET
QUINCY, MA 02169

********** PRODUCT NAME **********

**00006* MEMCO BRAND CREOSOTE PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 002458 WESTERN TAR PROD CORP
BOX 605
TERRA HAUTE IN 47808

********** PRODUCT NAME **********

**00004* CREOSOTE COAL TAR SOLUTION 60/40

**00006* CREOSOTE COAL TAR SOLUTION 70/30

**** PRODUCT SEARCH LISTING **** PAGE 25

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 002652 MILLER PURCELL COMPANY
P O BOX 245
NEW LENOX IL 60451

********** PRODUCT NAME **********

**00006* MPC CREOSOTE WOOD PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 002831 NAPASCO INTERNATIONAL, INC
PO DRAWER 1057
THIBADAUX, LA 70301

********** PRODUCT NAME **********

**00003* NAPASCO LARVA-KIL MOSQUITO LARVACIDE

****

REGISTRANT *NAME AND ADDRESS*

* 002836 LOCE & DILWORTH INC
BOX 25
BRISTOL PA 19007

********** PRODUCT NAME **********

**00002* SUPERIOR BRAND REFINED CREOSOTE OIL

**** PRODUCT SEARCH LISTING **** PAGE 26

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 002841 PHOENIX OIL COMPANY
625 5TH ST
AUGUSTA GA 30901

********** PRODUCT NAME **********

**C0010* PHOENIX CREOSOTE WOOD PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 002900 SHEPARDS CHEMICAL WORKS
P. O. BOX 473
WILMINGTON, NC 28401

********** PRODUCT NAME **********

**00006* SHEPARD'S CREOSOTE WOOD PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 003008 OSMOSE WOOD PRES COMPANY OF AMERICAN INC
980 ELLICOTT ST
BUFFALO NY 14209

********** PRODUCT NAME **********

**00015* OSMOPLASTIC - B

**** PRODUCT SEARCH LISTING **** PAGE 27

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 003098 BAXTER J H & COMPANY
1700 S EL CAMINO REAL
SAN MATEO CA 94402

********** PRODUCT NAME **********

**00009* J. H. BAXTER COAL TAR CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 003486 AMERICAN TAR COMPANY
1700 N NORTHLAKE WAY
SEATTLE WA 98103

********** PRODUCT NAME **********

**00001* ATCO TAR AND CREOSOTE

**00003* ATCO REFINED COAL TAR FREE FROM WATER

**00004* ATCO COMMERCIAL CREOSOTE OIL

****

REGISTRANT *NAME AND ADDRESS*

* 003635 OXFORD CHEMICALS
PO BOX 80202
ATLANTA GA 30341

********** PRODUCT NAME **********

**00033* SANFAX C.T. DISINFECTANT NO. 2

**** PRODUCT SEARCH LISTING **** PAGE 28

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 003742 WHITESIDES CO. INC. GEORGE W.
31ST & MICHIGAN DR
LOUISVILLE KY 40202

********** PRODUCT NAME **********

**00001* CREOSOTE OIL

****

REGISTRANT *NAME AND ADDRESS*

* 003770 ECONOMY PROD COMPANY
BOX 237
HOSPERS, IA 51238

********** PRODUCT NAME **********

**00150* COAL TAR DISINFECTANT CODE 5 FOR LIVESTOCK PREMISES

****

REGISTRANT *NAME AND ADDRESS*

* 003809 SOUTHWEST GREASE-OIL CO INC
KANSAS CITY DIV
BOX 1974 - 1400 SOUTH HARRISON
OLATHE, KS 66061

********** PRODUCT NAME **********

**00002* FORTRESS CREOSOTE WOOD PRESERVING SOLUTION READY TO USE

**00004* CREOSOTE WOOD PRESERVER CW-098

**** PRODUCT SEARCH LISTING **** PAGE 29

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 003862 AEC COMPOUNDING COMPANY
BOX 932
ATLANTA GA 30301

********** PRODUCT NAME **********

**00048* MOSQUITO LARVAECIDE

****

REGISTRANT *NAME AND ADDRESS*

* 004243 GINN J B & COMPANY
1401 GRATIOT ST
ST LOUIS MO 63103

********** PRODUCT NAME **********

**00005* GINN'S CREOSOTE PRESERVING OIL

****

REGISTRANT *NAME AND ADDRESS*

* 004464 STAY & DAY PAINT MATERIALS COMPANY
363 S MISSION RD
LOS ANGELES CA 90033

********** PRODUCT NAME **********

**00001* STADCO CREOSOTE

**** PRODUCT SEARCH LISTING **** PAGE 30

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 004627 DOUGLAS CHEMICAL CO
STAPLES MILL RD
RICHMOND, VA 23200

********** PRODUCT NAME **********

**00004* DOUGLAS CREOSOTE IN OIL

****

REGISTRANT *NAME AND ADDRESS*

* 004715 COLORADO INTERNATIONAL CORP
7800 MARBLE N.E.
ALBUQUERQUE, N.M. 87110

********** PRODUCT NAME **********

**00300* CREOSOTE 100 STANDARDIZED WOOD PRESERVING OIL

****

REGISTRANT *NAME AND ADDRESS*

* 004861 CLARKE & PROCTOR TURPENTINE COMPANY INC
BOX 194
FAYETTEVILLE NC 28304

********** PRODUCT NAME **********

**00002* C & P CREOSOTE OIL WOOD PRESERVATIVE

**** PRODUCT SEARCH LISTING **** PAGE 31

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 005266 FORESTRY ENTERPRISES INC
CHAPMAN CHEMICAL COMPANY 416 BROOKS RD
MEMPHIS TN 38109

********** PRODUCT NAME **********

**00009* K-BAN PC-15 WOOD PRESERVATIVE GREASE

****

REGISTRANT *NAME AND ADDRESS*

* 005285 MICELIN CHEM CORP
9045 VINCENT
DETROIT MI 48211

********** PRODUCT NAME **********

**00012* MISTER TEINZIT CREOSOTED WOOD PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 005351 FULTON CHEMICAL COMPANY
P O DRAWER 160
SUMTER SC 29150

********** PRODUCT NAME **********

**00005* FUL-O-TAR CREOSOTE 41-0998

**** PRODUCT SEARCH LISTING **** PAGE 32

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 005620 BOATMAN BILL & COMPANY
308 SOUTH MAPLE STREET
FAIRBRIDGE, OH 45612

********** PRODUCT NAME **********

**00004* B & B MANGE MAGIC FOR DOGS

****

REGISTRANT *NAME AND ADDRESS*

* 005831 GILSONITE INC
2946 NE COLUMBIA BLVD
PORTLAND OR 97211

********** PRODUCT NAME **********

**00005* BARTEL'S BEDY COAT SPECIFICATION CREOSOTE 450

**00007* BARTEL'S -EDY COAT COMMERCIAL CREOSOTE 451

****

REGISTRANT *NAME AND ADDRESS*

* 006035 VINELAND LABS INC
BOX 70
VINELAND NJ 08360

********** PRODUCT NAME **********

**00035* VINELAE CRESL-400 PHENOL COEFFICIENT-20 A.O.A.C. METHOD

**** PRODUCT SEARCH LISTING **** PAGE 33

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 006314 POLE TREATING CO.
BLAIR MILL ROAD
WILLOW GROVE, PA 19090

********** PRODUCT NAME **********

**00001* POLE-TOX WOOD PRESERVING COMPOUND

**00002* POLEX WOOD PRESERVING COMPOUND

****

REGISTRANT *NAME AND ADDRESS*

* 006354 NANKEE ALUMINUM PAINT CO INC
ENGINEER LANE
FARMINGDALE, NY 11735

********** PRODUCT NAME **********

**00003* NANKEE CREOSOTE WOOD PRESERVATIVE COMPOUND

****

REGISTRANT *NAME AND ADDRESS*

* 006730 [illegible]
3905 W WASHINGTON ST
DENVER CO 80216

********** PRODUCT NAME **********

**00003* POLE-AID NO. 3

**** PRODUCT SEARCH LISTING **** PAGE 34

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 006762 STERN CHEM CORP
BOX 5070
MONROE LA 71201

************ PRODUCT NAME **********

**00018* MOSQUITO LARVACIDE CONCENTRATED

****

REGISTRANT *NAME AND ADDRESS*

* 006823 WYCKOFF COMPANY
560 WHITE HENRY STUART BLDG
SEATTLE, WA 98101

********** PRODUCT NAME **********

**00001* CREOSOTE-PETROLEUM SOLUTION

**00003* PURE COAL TAR CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 006830 OCTAGON PROCESS INC
596 RIVER RD
EDGEWATER NJ 07020

********** PRODUCT NAME **********

**00041* 6810-257-2482 CREOSOTE, TECHNICAL WOOD PRESERVATIVE

**00043* CREOSOTE, COAL TAR, TECHNICAL FEDERAL SPECIFICATION TT-C-645A

**00083* OCTAGON BRAND PHENOLIC DISINFECTANT

**** PRODUCT SEARCH LISTING **** PAGE 35

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 007109 ST LOUIS PAINT MANUFACTURING COMPANY
2500 OHIO AVE
ST LOUIS MO 63104

********** PRODUCT NAME **********

**00003* CHECKER BRAND CREOSOTE PRESERVING OIL

****

REGISTRANT *NAME AND ADDRESS*

* 007135 SUNNYSIDE PRODUCTS INC
553C N WOLCOTT AVE
CHICAGO IL 60640

********** PRODUCT NAME **********

**00004* SUNNYSIDE REFINED CREOSOTE OIL

****

REGISTRANT *NAME AND ADDRESS*

* 007161 NATIONAL SOLVENT CORP
955 W SMITH RD
MEDINA OH 44256

********** PRODUCT NAME **********

**00002* NASCO CREOSOTE OIL

**** PRODUCT SEARCH LISTING **** PAGE 36

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 007234 FORSHAW CHEMICALS INC
650 STATE STREET PO BOX 6055
CHARLOTTE NC 28208

********** PRODUCT NAME **********

**00018* CREE PEN

****

REGISTRANT *NAME AND ADDRESS*

* 007342 WARNER-GRAHAM COMPANY
160 CHURCH LANE
COCKEYSVILLE MD 21030

********** PRODUCT NAME **********

**00001* GRACO PURE REFINED CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 007500 GIBSON-HOMANS COMPANY
2366 WOODHILL RD
CLEVELAND OH 44106

********** PRODUCT NAME **********

**00002* BLACK JACK CREOSOTE WOOD PRESERVER

**00004* BLACK JACK FORMULA 892 CREOSOTE WOOD PRESERVING COMPOUND

**00010* NORTHERN CREOSOTE WOOD PRESERVING COMPOUND

**** PRODUCT SEARCH LISTING **** PAGE 37

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 007832 BORDERLAND PROD INC.
BOX 366
BUFFALO NY 14240

********** PRODUCT NAME **********

**00001* STANLEY'S CROW REPELLENT

****

REGISTRANT *NAME AND ADDRESS*

* 007836 GARDNER ASPHALT PRODUCTS COMPANY
4001 E BROADWAY
TAMPA FL 33605

********** PRODUCT NAME **********

**00003* GARDNER OF FLORIDA CREOSOTE OIL GRADE NO. 1

****

REGISTRANT *NAME AND ADDRESS*

* 008081 DEWITT PRODUCTS COMPANY
5860 PLUMER AVE
DETROIT MI 48209

********** PRODUCT NAME **********

**00001* DEWITT'S CREOSOTED WOOD PRESERVATIVE

**** PRODUCT SEARCH LISTING **** PAGE 38

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 008259 SANIVAN LABS INC
1606 BURNT HILL RD
CHERRY HILL NJ 08034

********** PRODUCT NAME **********

**00003* SANIVAN'S CREOSOTE OIL COMPOUND

****

REGISTRANT *NAME AND ADDRESS*

* 008643 CROSBY FOREST PRODUCTS COMPANY
BOX 520
PICAYUNE MS 39466

********** PRODUCT NAME **********

**00006* CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 008898 WITCO CHEMICAL COMPANY INC
277 PARK AVE
NEW YORK NY 10017

********** PRODUCT NAME **********

**00011* COAL TAR CREOSOTE

**** PRODUCT SEARCH LISTING **** PAGE 39

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 009014 ZIMMERMAN E E COMPANY
HOFFMAN & KNOTT STS
N SIDE PITTSBURG PA 15222

********** PRODUCT NAME **********

**00001* E-Z CREOSOTE WOOD PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 009027 GILMAN PAINT & VARNISH COMPANY
BOX 1257
CHATTANOOGA TN 37401

********** PRODUCT NAME **********

**00003* GILMAN CREOSOTE WOOD PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 009639 WILLARD PRODUCTS
BOX 1249
REDWOOD CITY CA 94064

********** PRODUCT NAME **********

**00001* WILLARD QUALITY PRODUCTS CREOSOTE

**** PRODUCT SEARCH LISTING **** PAGE 40

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 009957 STERLING-CLARK-LURTON CORP
184 COMMERCIAL ST
MALDEN MA 02148

********** PRODUCT NAME **********

**00004* STERLING CREOSOTE WOOD PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 010054 GILBERT ROY W
669 SHADES CREST RD
BIRMINGHAM AL 35226

********** PRODUCT NAME **********

**00001* NUT-GON NUT GRASS KILLER

****

REGISTRANT *NAME AND ADDRESS*

* 010100 MELROSE CHEMICAL CO INC
763-46TH AVENUE
OAKLAND CA 94601

********** PRODUCT NAME **********

**00002* FSN 6810-257-2482 CREOSOTE, TECHNICAL

**** PRODUCT SEARCH LISTING **** PAGE 41

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 010545 VANCO PRODUCTS INC
438 SPRINGFIELD PIKE
CINCINNATI OH 45317

********** PRODUCT NAME **********

**00001* DARK CREOSOTE OIL WOOD PRESERVATIVE NON-CRYSTALIZING

****

REGISTRANT *NAME AND ADDRESS*

* 010569 J & P PETROLEUM PRODUCTS INC
PO BOX 4206 STA A
DALLAS TX 75208

********** PRODUCT NAME **********

**00002* TEX-MASTIC NO. 1 CREOSOTE WOOD PRESERVATIVE CODE NO. 524

****

REGISTRANT *NAME AND ADDRESS*

* 010727 MONSEY PRODUCTS COMPANY
COLDSTREAM RD
KIMBERTON PA 19442

********** PRODUCT NAME **********

**00001* MONSEY L-11 CREOSOTE WOOD PRESERVING COMPOUND

**00002* GUARDSEAL WOOD PRESERVING COMPOUND (DARK)

**** PRODUCT SEARCH LISTING **** PAGE 42

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COAL TAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 010771 ADAMS ENGINEERING INC
P. O. BOX 3
STACY MN 55079

********** PRODUCT NAME **********

**00002* PATOX POLE TREATING BANDAGE I

**00003* PATOX POLE TREATING BANDAGE TYPE III

****

REGISTRANT *NAME AND ADDRESS*

* 011092 MARVIN CORP THE
1641 BLUFF RD
MONTEBELLO CA 90640

********** PRODUCT NAME **********

**00001* MARVIN WOOD PRESERVATIVE CREOSOTE NO. 118

****

REGISTRANT *NAME AND ADDRESS*

* 011291 PARKS CORPORATION
PO BOX 5
SOMERSET MA 02726

********** PRODUCT NAME **********

**00002* CREOSOTE PRESERVATIVE

**** PRODUCT SEARCH LISTING **** PAGE 43

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 011554 COLUMBIA PAINT CORPORATION
P.O. BOX 2888
HUNTINGTON WV 25728

********** PRODUCT NAME **********

**00001* CPC COLUMBIA CREOSOTE OIL WOOD PRESERVATIVE BLACK

**00002* CPC COLUMBIA AWPA NO. 1 CREOSOTE OIL DARK AMBER

****

REGISTRANT *NAME AND ADDRESS*

* 011614 TRI STATE SUPPLY INC
BOX 9505
DENVER CO 80209

********** PRODUCT NAME **********

**00001* COLORADO CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 011668 T & R CHEMICALS, INC.
700 CEKUM ROAD
CLINT, TX 79836

********** PRODUCT NAME **********

**00001* T & R CREOSOTE WOOD PRESERVING SOLUTION

**** PRODUCT SEARCH LISTING **** PAGE 44

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 011690 AMERICAN SEAL MANUFACTURING COMPANY INC
669 RIVER ST
TROY NY 12180

********** PRODUCT NAME **********

**00001* NO-D-K CREOSOTE OIL

****

REGISTRANT *NAME AND ADDRESS*

* 013895 AMERICAN CREOSOTE WORKS INC
PO BOX 4008
NEW ORLEANS LA 70118

********** PRODUCT NAME **********

**00001* CREOSOTE OIL

****

REGISTRANT *NAME AND ADDRESS*

* 014820 VAN'S INSECT REPELLANT COMPANY
BOX 152
WATERSMEET, MI 49969

********** PRODUCT NAME **********

**00001* VAN'S SHIELD INSECT REPELLENT

**** PRODUCT SEARCH LISTING **** PAGE 45

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COAL TAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 031969 BENFIELD INDUSTRIES, INC.
165 OLD CLYDE ROAD
CANTON NC 28716

********** PRODUCT NAME **********

**00003* SOUTHERN PINE CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 033834 ECOLOGICAL AND SPECIALIST PROD., INC.
11-5 AVE
PATTERSON, NJ 07514

********** PRODUCT NAME **********

**00001* ACTION CREOSOTE WOOD PRESERVATIVE

**00002* CRESOTE OIL COMPOUND

****

REGISTRANT *NAME AND ADDRESS*

* 034276 CENTURY INDUSTRIES CORP
RD #1
NEW WATERFORD, OH 44445

********** PRODUCT NAME **********

**00002* CREOSOTE WOOD PRESERVER

**** PRODUCT SEARCH LISTING **** PAGE 46

07/14/78 FEDERALLY REGISTERED PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 034882 ROBERTS PROPRIETORIES INC
41 EAST 57TH STREET
NEW YORK, NY 10022

********** PRODUCT NAME **********

**00002* VETERNARY V.C.P.

****

REGISTRANT *NAME AND ADDRESS*

* 035666 M. J. DALY CO., INC.
38 ELM STREET
LUDIOW, KY 41016

********** PRODUCT NAME **********

**00001* DARK CRECSOTE WOOD PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 038350 THE WOOLFOAM CORPORATION
1 WEST 37TH STREET
NEW YORK, NY 10018

********** PRODUCT NAME **********

**00001* CREOLIN GENERAL PURPOSE DISINFECTANT

**** PRODUCT SEARCH LISTING **** PAGE 1

07/14/78 APPLICANTS FOR REGISTRATION OF PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 000422 BLUE BALL CHEMICAL COMPANY
914 HOFFNER AVENUE
ORLANDO FL 32809

********** PRODUCT NAME **********

**05380* BILLS DIP FOR DOGS & HORSES

**05382* BLUE BALL MANGE & ITCH TREATMENT

**05385* OUR PET MANGE TREATMENT

****

REGISTRANT *NAME AND ADDRESS*

* 001969 PARSONS CHEMICAL
BOX 146
GRAND LEDGE MI 48837

********** PRODUCT NAME **********

**03301* PARSONS SEED SAVER CROW REPELLENT

****

REGISTRANT *NAME AND ADDRESS*

* 002439 APPERTON CHEMICAL COMPANY
PO BOX 2555 2903 STRICKLAND ST
JACKSONVILLE FL

********** PRODUCT NAME **********

**04368* DARK CREOSOTE

**** PRODUCT SEARCH LISTING **** PAGE 2

07/14/78 APPLICANTS FOR REGISTRATION OF PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 003286 FERD STAFFEL CO.
P.O. BOX 2380
SAN ANTONIO TX 78298

********** PRODUCT NAME **********

**08063* STAFFEL'S TREE DRESSING

****

REGISTRANT *NAME AND ADDRESS*

* 003509 SAFE WAY FARM PRODUCTS COMPANY
2519 E FIFTH ST
AUSTIN TX 78702

********** PRODUCT NAME **********

**05495* CRESO-DIP

****

REGISTRANT *NAME AND ADDRESS*

* 006853 BES TEX INSECTICIDES
713 S. OAKES PO BOX 664
SAN ANGELO TX 76901

********** PRODUCT NAME **********

**07347* BES-TEX CRESO-DIP

**** PRODUCT SEARCH LISTING **** PAGE 3

07/14/78 APPLICANTS FOR REGISTRATION OF PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 007109 ST LOUIS PAINT MANUFACTURING COMPANY
2500 OHIO AVE
ST LOUIS MO 63104

********** PRODUCT NAME **********

**06805* SHURWAY CREOSOTE OIL PAINT

****

REGISTRANT *NAME AND ADDRESS*

* 009369 JOHNSON DL
RT 9 BOX 268
PENSACOLA FL 32503

********** PRODUCT NAME **********

**09377* JOHNSON'S MANGE MAGIC

****

REGISTRANT *NAME AND ADDRESS*

* 010727 MONSEY PRODUCTS COMPANY
COLDSTREAM RD
KINNERTON PA 19442

********** PRODUCT NAME **********

**09017* MONSEY L11 CREOSOTE WOOD PRESERVING COMPOUND

**09019* GUARDSEAL WOOD PRESERVATIVE COMPOUND (DARK)

**** PRODUCT SEARCH LISTING **** PAGE 4

07/14/78 APPLICANTS FOR REGISTRATION OF PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 010827 INDUSTRIAL SOLVENTS
PO BOX 312
SAN MARCOS TX 78666

********** PRODUCT NAME **********

**03417* IND-SOL 80

****

REGISTRANT *NAME AND ADDRESS*

* 014961 REX CHEMICAL
2300 NW 23RD ST
MIAMI FL 33142

********** PRODUCT NAME **********

**04419* CREOLINA

****

REGISTRANT *NAME AND ADDRESS*

* 022058 SHARP CHEMICAL COMPANY
5921 PLAINVIEW
HOUSTON TX 77017

********** PRODUCT NAME **********

**07470* COAL TAR DISINFECTANT

**** PRODUCT SEARCH LISTING **** PAGE 5

07/14/78 APPLICANTS FOR REGISTRATION OF PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 033840 WILLIAMSON PAINT MFG CO INC
P O BOX 6066
CHARLESTON, WV 25302

********** PRODUCT NAME **********

**10473* "ROT NOT" CREOSOTE WOOD PRESERVER

**10474* "ROT NOT" RAW CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* C34800 M G CHEMICAL
222 21ST STREET
HIALEAH, FL 33010

********** PRODUCT NAME **********

**05386* CRESOL,BLACK DISINFECTANT

****

REGISTRANT *NAME AND ADDRESS*

* 036688 BIG BEE CHEMICAL AND SUPPLY CO.
ROUTE 4 OLD CONYERS ROAD
STOCKBRIDGE, GA 30281

********** PRODUCT NAME **********

**08204* MOSQUITO LARVACIDE

**** PRODUCT SEARCH LISTING **** PAGE 6

07/14/78 APPLICANTS FOR REGISTRATION OF PRODUCTS CONTAINING COALTAR, CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 037805 CONCORDIA FARMERS CO.
COPERATIVE COMPANY
CONCORDIA, MO 64020

********** PRODUCT NAME **********

**08372* CREOSOTE OIL WOOD PRESERVATIVE

****

REGISTRANT *NAME AND ADDRESS*

* 037865 GRAEN MFG. CO., INC.
7605 E. 17TH STREET
KANSAS CITY, MO 64126

********** PRODUCT NAME **********

**08154* GRAHNS COAL TAR CREOSOTE

****

REGISTRANT *NAME AND ADDRESS*

* 037919 ROBERTS-JUDSON LUMBER COMPANY
301 EAST 4TH STREET
SALEM, MO 65560

********** PRODUCT NAME **********

**09423* TOLOLEUM-CREOSOTE

[FR Doc. 78-28934 Filed 10-17-78; 8:45 am]

[6560-01-M]

[FRL 984-3; OPP-30000/29]

PESTICIDE PROGRAMS

Notice of Rebuttable Presumption Against Registration and Continued Registration of Pesticide Products Containing Inorganic Arsenic

AGENCY: Office of Pesticide Programs, Environmental Protection Agency (EPA).

ACTION: Notice of rebuttable presumption.

SUMMARY: Inorganic arsenic has been found to exceed certain risk criteria set forth in 40 CFR 162.11. This notice requests registrants and other interested persons to submit rebuttals and other information on the presumption and to submit any other data on the risks and benefits of this pesticide chemical. This notice is the first of several which will give public notification of the Agency's progress in reviewing this chemical. Today EPA is also publishing in the FEDERAL REGISTER notices of rebuttable presumption against registration (RPAR) on pentachlorophenol (PCP) and coal tar, creosote, and coal tar neutral oil. Since inorganic arsenic, PCP, and coal tar and its derivatives comprise the most widely used of pesticide wood treatments available, the wood treatment uses of these pesticides will be considered together in the risk/benefit part of the RPAR review process. Other uses for these pesticides will be considered in individual risk/benefit analyses for each chemical.

DATE: Rebuttal evidence and other information must be received on or before December 4, 1978.

ADDRESS MATERIAL TO: Federal Register Section, Program Support Division (TS-757), Office of Pesticide Programs, EPA, Room, 401, East Tower, 401 M Street SW., Washington, D.C. 20460.

FOR FURTHER INFORMATION CONTACT:

William Waugh or Anita Schmidt, Special Pesticide Review Division, Office of Pesticide Programs (TS-791), Room 447, East Tower, EPA, 202-755-5755.

SUPPLEMENATARY INFORMATION: The Deputy Assistant Administrator, Office of Pesticide Programs, EPA, has determined that a rebuttable presumption exists against registration and continued registration of all pesticide products containing inorganic arsenic.[1]

Issuance of this RPAR means that potential adverse effects associated with the use of inorganic arsenic have been identified and will be examined further to determine if they do exist and, if so, whether they are unreasonable. This process involves a public review of both the risks and the benefits associated with the uses of the pesticide. The RPAR does not mean that the Agency has decided to cancel or suspend the registration of this pesticide or to take any other action with respect to it; EPA has not made a finding that use of any products containing this ingredient presents an imminent hazard. Any pesticide subject to this RPAR may lawfully be sold, distributed, and used for all uses for which it is registered and labeled.

I. REGULATORY PROVISIONS

A. *General.* Title 40, part 162.11, of the Code of Federal Regulations for the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended (86 Stat. 973, 89 Stat. 751, 7 U.S.C. 136 et seq.), provides that a rebuttable presumption against registration shall arise if the Agency determines that a pesticide meets or exceeds any of the risk criteria relating to acute and chronic toxic effects set forth in section 162.11(a)(3). If it is determined that such a rebuttable presumption has arisen, the regulations require that the registrant be notified by certified mail and afforded an opportunity to sumbit evidence in rebuttal of the presumption. In addition, the Agency has determined that the public should also be given notice of the bases for the presumption to provide an opportunity for comment and to solicit additional information relevant to the presumption.

A notice of rebuttable presumption against registration is issued when the evidence related to risk meets the criteria set forth in section 162.11(a)(3). It is emphasized that a notice of rebuttable presumption against registration and continued registration of a pesticide is not a notice of intent to cancel the registration of a pesticide, and may or may not lead to cancellation. The notice of intent to cancel is issued only after the risks and benefits of a pesticide are carefully considered and it is determined that the pesticide may generally cause unreasonable adverse effects to the environmnet.

All registrants and applicants for registration are invited pursuant to 40 CFR 162.11(a)(4) to submit evidence in rebuttal of the presumptions listed in part II of this notice and, in the case of oncogenicity, to submit information which relates to the assessment of oncogenic risks as set forth in the Agency's Interim Procedures and Guidelines for Health Risk and Economic Impact Assessment of Suspected Carcinogens (May 25, 1976; 41 FR 21402). Registrants and other interested parties may submit for consideration data on benefits which they believe would justify registration or continued registration. In addition, any registrant may petition the Agency to voluntarily cancel a current registration pursuant to section 6(a)(1) of FIFRA.

B. *Rebuttal criteria.* Section 162.11(a)(4) provides that a registrant may rebut the presumption by sustaining the burden of proving:

(1) In the case of a pesticide presumed against pursuant to the acute toxicity or lack of emergency treatment criteria, "that when considered with the formulation, packaging, method of use, and proposed restrictions on the directions for use and widespread and commonly recognized practices of use, the anticipated exposure to an applicator or user and to local, regional, or national populations of nontarget organisms is not likely to result in any significant acute adverse effects" [40 CFR 162.11(a)(4)(i)];

(2) In the case of a pesticide presumed against pursuant to the chronic toxicity criteria, "that when considered with proposed restrictions on use and widespread and commonly recognized practices of use, the pesticide will not concentrate, persist or accrue to levels in man or the environment likely to result in any significant chronic adverse effects" [40 CFR 162.11(a)(4)(ii)]; or

(3) In either case, that "the determination by the Agency that the pesticide meets or exceeds any of the criteria for risk was in error" [40 CFR 162.11(a)(4)(iii)].

C. *Benefits information.* In addition to submitting evidence to rebut the presumption of risk, section 162.11(a)(5)(iii) provides that a registrant "may submit evidence as to whether the economic, social, and environmental benefits of the use of the pesticide subject to the presumption outweigh the risk of use." If the risk presumptions are not rebutted, the benefit evidence[2] submitted by the

[1] A position document, containing an appendix of references, background information, and other material pertinent to the issuance of this notice, has been prepared by the Agency on inorganic arsenic and is also published with this notice.

[2] Registrants or other interested persons who desire to submit benefit information should consider submitting information on the following subjects, along with any other relevant information they desire to submit:

1. Identification of the minor uses of the pesticide, including estimated quantities used by crop or other application.

2. Identification of the major uses of the pesticide, including estimated quantities used by category such as lawn and garden uses and household uses.

3. Identification of registered alternative products for the uses set forth in (1) and (2) above, including an estimate of their availability.

4. Determination of the change in costs to the user of providing equivalent pesticide

Footnotes continued on next page

registrant, applicants, and other interested persons will be considered by the Administrator in determining the appropriate regulatory action. Specifically, section 162.11(a)(5)(iii) provides that if the benefits appear to outweigh the risks, the Administrator may issue a notice of intent to hold a hearing pursuant to section 6(b)(2) of FIFRA to determine whether the registration(s) should be cancelled or application(s) denied. Alternatively, if the "benefits do not appear to outweigh the risks, the Administrator shall issue a notice pursuant to section 3(c)(6) or section 6(b)(1) of the Act, as appropriate." Moreover, if at any time the Administrator determines that a pesticide poses an "imminent hazard" to humans or the environment, a notice of suspension may be issued pursuant to section 6(c) of the Act.

II. Presumptions

Registrations and applications for registration of pesticide products containing inorganic arsenic meet or exceed the 40 CFR 162.11(a)(3) risk criteria relating to oncogenic effects (human epidemiology studies), mutagenic effects, and reproductive or fetotoxic effects in mammalian test species. The Agency's basis for concluding that these risk criteria have been met or exceeded is set out in "Inorganic Arsenic: Position Document 1," which follows. Copies of attachments to the position document which are not published with this notice are available for public inspection in the office of the Special Pesticide Review Division. Information protected from disclosure pursuant to FIFRA Section 10 cannot be provided. Specific inquiries concerning the position document, as well as requests for access to these files, should be directed to Project Managers William Waugh or Anita Schmidt, Special Pesticide Review Division (TS-791), EPA, Room 447, East Tower, 401 M Street SW., Washington, D.C. 20460, 202-755-5755.

A. *Oncogenicity.* 40 CFR Section 162.11(a)(3)(ii)(A) provides that a rebuttable presumption shall arise if a pesticide "(i)nduces oncogenic effects in experimental mammalian species or in man as a result of oral, inhalation, or dermal exposure * * *." As a further clarification of the provision, the preamble to the Agency's Interim Procedures and Guidelines for Health Risk and Economic Impact Assessment of Suspected Carcinogens [May 25, 1976; 41 Fr 21402] states that "a substance will be considered a presumptive cancer risk when it causes a statistically significant excess incidence of benign or maliganant tumors in humans or animals."

On the basis of scientific studies and information summarized in the position document, the Agency has concluded that all registrations and applications for registration of pesticide products containing inorganic arsenic exceed this risk ciriterion, and that a rebuttable presumption against new or continued registration of such products has arisen.

B. *Mutagenicity.* 40 CFR Section 162.11(a)(3)(ii)(A) provide that a rebuttable presumption shall arise if a pesticide "* * * induces mutagenic effects, as determined by multitest evidence."

On the basis of scientific studies and information summarized in the position document, the Agency has concluded that all registrations and applications for registration of pesticide products containing inorganic arsenic exceed this risk criterion, and that a rebuttable presumption against new or continued registration of such products has arisen.

C. *Other chronic or delayed toxic effects.* 40 CFR Section 162.11(a)(3)(ii)(B) provides that a rebuttable presumption shall arise if a pesticide "(p)roduces any other chronic or delayed toxic effect in test animals at any dosage up to a level, as determined by the Administrator, which is substantially higher than that to which humans can reasonably be anticipated to be exposed, taking into account ample margins of safety * * *."

On the basis of scientific studies and information summarized in the position document, the Agency has concluded that all registrations and applications for registration of pesticide products containing inorganic arsenic exceed this risk criterion for reproductive or fetotoxic effects and that a rebuttable presumption against new or continued registration of such products has arisen.

Additional Grounds for Review

As discussed in detail in the attached position document, some data has associated inorganic arsenic with delayed neurotoxicity and population reduction in nontarget aquatic and mammalian species. The data and analyses available at this time with respect to these effects are not sufficient to warrant the issuance of a rebuttable presumption. The Agency specifically solicits further evidence bearing on these possible adverse effects. All comments and information received with respect to the potential adverse effects, includig analysis thereof, may serve as a basis for a final decision on registering pesticides containing inorganic arsenic.

IV. Rebuttal Submission Procedures

All registrants and applicants for registation listed below are being notified by certified mail of the rebuttable presumption existing against registration and continued registration of their products.

The registrants and applicants for registration shall have 45 days from the date this notice is sent of until December 4, 1978, to submit evidence in rebuttal of the presumption. However, the Adminstrator may, for good cause shown, grant an additional 60 days during which such evidence may be submitted. Notice of such an extension, if granted, will appear in the Federal Register.

A registrant or applicant for registration, may, if it desires, assert a business confidentiality claim covering part or all of the information submitted in rebuttal. The registrant or applicant may assert the claim by placing on or attaching to the information a cover sheet, stamped or typed legend, or other suitable form of notice employing language such as "trade secret," "proprietary," or "company confidential." Allegedly confidential portions of otherwise nonconfidential documents should be clearly marked.

If a confidentiality claim is asserted, the information covered by the claim will be disclosed by EPA only to the extent and by means of the procedures set forth in 40 CFR Part 2, Subpart B (41 FR 36906; September 1, 1976). If no confidentiality claim accompanies the information at the time it is received by EPA, EPA will place the information in the public comment file where it will be available for public inspection.

If a registrant of applicant does assert a confidentiality claim for some but not all, of the information submitted to EPA in rebuttal, the registrant or applicant should furnish two copies of the information to EPA. The first copy should contain all of the information submitted in rebuttal with information claimed as confidential clearly identified. The second copy should be identical to the first except that all information claimed as confidential should be deleted. The second copy will be placed in the public comment file. The first copy will be treated in accordance with the procedures set out above.

Footnotes continued from last page

treatment with any available substitute products.

5. Assessment of regulation impact upon user productivity (e.g., yield per acre and/or total output) from using available substitute pesticides or from using no other pesticides.

6. If the impacts upon either user costs or productivity are significant, a qualitative assessment of the regulation's impact on production of major agricultural commodities and retail food prices of such commodities.

V. Duty To Submit Information on Adverse Effects

Registrants are required by law to submit to EPA any additional information regarding any adverse effects on man or the environment which comes to a registrant's attention at any time, pursuant to section 6(a)(2) of FIFRA and 40 CFR 162.8(d). If any registrant of inorganic arsenic products has any published or unpublished information, studies, reports, analyses, or reanalyses regarding any adverse effects in animal species or humans, residues, and claimed or verified accidents to humans, domestic animals, or wildlife, which have not been previously submitted to EPA, the material must be submitted immediately. When responding to this notice, each registrant shall submit a written certification to the Agency that all information regarding any adverse effects known to the registrant has been submitted. In addition, the registrants should notify EPA of any studies currently in progress, including the purpose of the study, the protocol, the approximate completion date, and a summary of all results observed to date.

VI. Public Comments and Inspection

During the time allowed for submission of rebuttal evidence, specific comments on the presumptions set forth in this notice and on the material contained in the position document are solicited from the public. In particular, any documented episodes of adverse effects to humans, domestic animals, or wildlife, and information as to any laboratory studies in progress or completed are requested to be submitted to EPA as soon as possible. Specifically, information on the fate and effects of inorganic arsenic, its impurities, metabolites, and degradation products on flora and fauna, particularly animals with metabolism similar to man, is solicited. Similarly, any studies or comments on the benefits from the use of inorganic arsenic are requested to be submitted. All comments and information received, as well as any other relevant information and analysis thereof, which come to the attention of the Agency may serve as a basis for final determination pursuant to section 162.11(a)(5).

All comments and information should be sent to the office of the Federal Register Section at the address given above, if possible in triplicate to facilitate the work of the Agency and others interested in inspecting them. The comments and information should bear the identifying notation "OPP-30000/29." Comments received after the specified time SSF period will be considered only to the extent feasible, consistent with the time limits imposed by 40 CFR Section 162.11(a)(5)(ii).

All written comments and information filed pursuant to this notice will be available for public inspection in the office of the Federal Register Section from 8:30 a.m. to 4 p.m. during normal working days. Interested persons are encouraged to take advantage of the opportunity to inspect Agency files during normal working hours since (1) all of the information recieved may serve as a basis for final determination pursuant to section 162.11(a)(5) and (2) the Agency will not generally publish a summary of information recieved in the Federal Register at the close of the rebuttal period.

Your cooperation is solicited in identifying any errors or omissions which may have been made in the following computer listings. Corrections to the listings may not necessarily be published in the Federal Register, but rather handled by mail with affected parties. Omissions will be corrected by notice in the Federal Register.

Dated: September 30, 1978.

Edwin L. Johnson,
Deputy Assistant Administrator for Pesticide Programs.

[6560-01-C]

INORGANIC ARSENICALS

Position Document 1

William T. Waugh
and
Anita L. Schmidt
Project Managers

INORGANIC ARSENICALS (Arsenic Acid, Arsenic Pentoxide, Arsenic Trioxide, Sodium Arsenate, Ammonium Arsenite, Sodium Pyroarsenate, Lead Arsenate (Standard and Basic), Calcium Arsenate, Sodium Arsenite, and Copper Acetoarsenite): POSITION DOCUMENT 1

SUMMARY

Arsenic is an ubiquitous element that occurs naturally in soil, water, microorganisms, plants, animals, and humans. This document focuses on those pesticides containing inorganic arsenic (ammonium arsenite, arsenic acid, arsenic pentoxide, arsenic trioxide, calcium arsenate, copper acetoarsenite, lead arsenate, sodium arsenite, sodium arsenate, and sodium pyroarsenate). These pesticides are in the form of either arsenite or arsenate, both of which are found in nature.

Inorganic arsenicals were among the first chemical insecticides used, and they are still being used today as insecticides, herbicides, wood preservatives, and as a maturing agent for grapefruit. Tolerance levels for residues of inorganic arsenic pesticides have been set by EPA for various foods such as fruit, vegetables, and meats. Arsenic also occurs in food and feed as a natural constitutent.

Absorption of inorganic arsenic (from natural and pesticide sources) by plants from soil, water, and air is influenced by several factors. Aquatic animals ingest or absorb arsenic directly from the surrounding water; terrestrial animals are exposed primarily by ingestion of contaminated feed. Exposure to humans, primarily from pesticides and smelters, is by ingestion, inhalation, and absorption through the skin. In mammals, arsenite and arsenate are differentially absorbed through various body tissues (i.e., skin, lungs, digestive tract).

Arsenic is distributed in plant tissues primarily in the roots and vegetative tissues; fruits usually have the lowest levels of arsenic. Arsenic distribution in animals is influenced by several factors such as the form of arsenic, species of animal, and route of exposure (oral, dermal, inhalation). In mammals, including humans, inorganic arsenic is distributed primarily in the liver, lungs, kidney, and spleen. There are also high levels of arsenic bound in hair and nail tissue. Since arsenic is a natural environmental contaminant, it is always present in human and animal tissues. The normal adult human body contains an estimated 15 to 20 mg of arsenic.

The biochemical mechanisms of toxic action for arsenate and arsenite differ: arsenate blocks the formation

of high energy compounds needed for cellular metabolism, and arsenite binds to proteins and inhibits the activity of several important enzymes. Arsenic does not normally build up beyond trace levels in mammalian tissues because a dynamic equilibrium is apparently reached between normal intake and excretion. Arsenite and arsenate are excreted at different rates: arsenate is generally excreted quickly from the body by the kidney, while arsenite is slowly excreted as it is released from tissue proteins to which it is bound.

Inorganic arsenic can be converted from one form to another by the metabolic activity of plant and animal cells. This is called biotransformation. In humans the conversion of arsenite to arsenate is favored, but animal studies have shown that arsenate can also be converted to arsenite. Both forms can also be converted to organic arsenic compounds such as methylarsenates. In soil, sediments of rivers and lakes, and water, transformation of arsenic (primarily to volatile organic forms) is mediated by microorganisms under both aerobic (oxygen present) and anaerobic (no oxygen present) conditions.

Although there are several sources of inorganic arsenic (i.e., natural weathering of arsenic-containing rock, smelters, volcanic debris, and pesticides),

residues from pesticides are a major source of arsenic pollution of soil, water, and air, and are the most widely distributed in the environment. Adsorption (adhesion) of arsenic to soil particles is dependent on several factors, and the adsorbed arsenic is fixed in the soil and is slightly soluble. The soluble unfixed arsenic is subject to leaching. Arsenic is naturally removed from the soil by volatilization (from biotransformation), leaching, wind-born dust, run-off, and plant uptake. Residues in soil from pesticide use are concentrated in the surface layers, and leaching usually occurs at a rate approximately equal to the addition of more pesticide. However, in some cases (i.e., apple orchards in Washington state), the extensive use of inorganic arsenicals has exceeded the leaching rate and rendered the soil very toxic to plants.

The content of arsenic is higher in sea water than in fresh water, except for fresh water near natural deposits of arsenic, areas of volcanic activity, or near pollution sources such as pesticide run-off. There is an equilibrium between arsenite and arsenate in sea water. In the upper oxidizing layers of the ocean, arsenic is primarily in the arsenate form; in the lower areas where reduction occurs, it is most often in the arsenite form. Arsenic is removed from solution by volatilization (from biotransformation) and adsorption by sediments.

Arsenic in air results primarily from human activities (i.e., smelting metals, ginning cotton, applying pesticides) and to a lesser extent from volcanic and bacterial action. Arsenic moves in air adsorbed to particulate matter and returns to soil by direct fallout and precipitation.

Arsenic apparently does not biomagnify: inorganic arsenic residues from pesticide use are not transferred from lower to higher organisms in the food chain, and therefore a greater concentration of arsenic does not occur in higher organisms than is present in lower forms. However, arsenic does bioaccumulate: residues can build-up in certain species. Due to the higher concentration of arsenic in salt water, marine organisms (plant and animal) tend to accumulate arsenic to a greater extent than freshwater forms. Lower food chain forms (plankton) usually have the highest arsenic residues.

The oncogenic, mutagenic, and teratogenic effects of inorganic arsenical pesticides are described in studies presented in this document. These effects are due to the action of the arsenate or arsenite portion of the parent compound rather than the compound as a whole (i.e., lead arsenate, sodium arsenite).

Therefore, if any arsenite form of arsenic produces a given effect, it is assumed that all arsenites are capable of producing the effect. The same is assumed for arsenates. There is also interconversion of the two forms in the body (arsenate reduced to arsenite, arsenite oxidized to arsenate). In mammals, conversion of arsenite to arsenate in the body is well documented. There is also evidence that arsenate can convert to arsenite *in vivo*, but this is less well-documented.

Arsenic is unique as a suspect carcinogen because an animal testing system has not yet been found that produces a carcinogenic response in rodents. There are numerous human epidemiology studies, however, which describe oncogenic effects from long-term exposure to arsenite and arsenate. These include the chronic use of potassium arsenite (Fowler's solution) for medical treatment of psoriasis and other conditions, chronic exposure to high levels of arsenic (form unknown) in drinking water, chronic exposure to arsenic trioxide (arsenite) in smelters and pesticide manufacturing plants, and chronic exposure to arsenate and arsenite in pesticide manufacturing plants and to insecticides in vineyards. The Agency concludes that sufficient epidemiological data exists to show that both forms of arsenic act as oncogens in humans and therefore recommends that an RPAR be issued against each inorganic arsenical pesticide.

There are many different tests that show arsenate and arsenite are mutagens (produce heritable genetic change) in bacterial cells, cultured human cells, and in rodents. The effects seen are point mutations (bacterial cells), inhibition of a DNA repair system and of DNA synthesis (cultured human epidermal cells), dominant-lethal effects (mice), chromosome effects such as sister chromatid exchange (cultured human lymphocytes), and translocations, aneuploidy, and chromatid breakage (cultured human leukocytes and lymphocytes). EPA concludes that sufficient data exist to show that both forms of arsenic produce mutagenic effects and therefore recommends that an RPAR be issued against each inorganic arsenical pesticide.

There are numerous studies that show arsenate and arsenite are teratogens (produce birth defects). In these studies, pregnant mice, rats, and hamsters were given arsenic either orally or by injection. Both forms of arsenic produced external body, soft tissue, and skeletal malformations, but arsenite produced these defects at lower doses than arsenate. EPA concludes that there is sufficient evidence that both forms of arsenic display teratogenic effects. Based on the level of exposure of each arsenical pesticide to a 60-kg woman (see Section III), EPA further concludes that an ample margin of safety does not exist for any use of the inorganic arsenicals and recommends that an RPAR be issued against these pesticides.

I. BACKGROUND

A. Chemical/Physical Characteristics

Arsenic occurs in both organic and inorganic forms. Organic arsenic differs from inorganic in that organic forms usually contain carbon (EPA 1976a).

The chemistry of arsenic is complex because arsenic can have multiple valence states. Each valence state of arsenic exhibits distinctly different chemical properties. Arsenic acid, arsenic pentoxide, calcium arsenate, lead arsenate, sodium arsenate, and sodium pyroarsenate are pentavalent arsenicals; ammonium arsenite, arsenic trioxide, copper acetoarsenite, and sodium arsenite are trivalent arsenicals. Knowledge of the conditions that promote interconversions between valence states, particularly those that promote the prevalence of trivalent arsenic, is important in evaluating the environmental effects of arsenic (Oak Ridge 1976).

(1) Pentavalent Arsenicals

(a) Arsenic Acid

Arsenic acid, an inorganic arsenical desiccant and herbicide, is the common name for orthoarsenic acid. The chemical formula is H_3AsO_4; the molecular weight is 151.1; and the density is 2.0 to 2.5 (Meister 1977). It exists as

white, translucent crystals at 20°C. The melting point is 35.5°C, and the boiling point is 160°C in the anhydrous state. The solubility of arsenic acid in water is 167 g/liter (Oak Ridge 1976).

(b) Arsenic Pentoxide

Arsenic pentoxide is an inorganic arsenical wood preservative, and an intermediate in the production of metal arsenates. The chemical formula is As_2O_3; the molecular weight is 229.8; and the density is 4.3. It exists as a white, amorphous solid. Arsenic pentoxide decomposes at 315°C and is very soluble in water, 1500 g/liter (Oak Ridge 1976).

(c) Sodium Arsenate

Sodium arsenate is an inorganic arsenical wood preservative and insecticide. The chemical formula is Na_2HAsO_4; the molecular weight is 129.9, and the density is 1.9. It exists as a grey-white powder and is very soluble in water (Oak Ridge 1976).

(d) Sodium Pyroarsenate

Sodium pyroarsenate is an inorganic arsenical wood preservative. The chemical formula is $Na_4As_2O_7$; the molecular weight is 353.79, and the density is 2.2. It exists as white crystals and decomposes at 1,000°C. The melting point is 850°C. It is very soluble in water (Weast 1977).

(e) Lead Arsenate (Standard and Basic)

Lead arsenate, an inorganic arsenical insecticide, is manufactured from arsenic acid, which in turn is made from arsenic trioxide (EPA 1976b). There are two forms of lead arsenate, standard and basic. Standard (or acid) lead arsenate is the common name for acid orthoarsenate ($PbHAsO_4$). Basic lead arsenate is the common name for basic orthoarsenate ($Pb_4(PbOH)(AsO_4)_3$, which exists as a white crystal at 20°C. The molecular weight is 899.4, and the density is 7.8. Its melting point is 1,042°C, and it is very slightly soluble in water (Oak Ridge 1976). Lead arsenate is not decomposed as readily as other arsenicals and is less likely to be phytotoxic (Meister 1977). (See Section I.I for a discussion of the chronic effects of lead.)

(f) Calcium Arsenate

Calcium arsenate is an inorganic arsenical insecticide and herbicide, which, like lead arsenate, is formulated from arsenic acid (EPA 1976b). The chemical formula is $Ca_3(AsO_4)_2$. Its molecular weight is 398.1, and its density is 3.6. Its solubility in water is 0.13 g/liter (Oak Ridge 1976). Calcium arsenate is somewhat unstable. Although it contains no more water-soluble arsenic than lead

arsenate when freshly manufactured, the action of carbonic acid and dilute alkaline solutions decomposes calcium arsenate, liberating the water soluble form. As a result, it must be used with quantities of lime to avoid injury to some plants (Meister 1977).

(2) Trivalent Arsenicals

(a) Ammonium Arsenite

Ammonium arsenite (also ammonium metaarsenite) is an inorganic arsenical wood preservative. The chemical formula is NH_4AsO_2; its molecular weight is 125, and the density is 1.3. It forms colorless, hygroscopic rhombic prisms. It is very soluble in cold water and decomposes in hot water (Weast 1977).

(b) Arsenic Trioxide

Arsenic trioxide, an inorganic arsenical rodenticide, is the common name for arsenious (or arsenous) oxide; refined arsenic trioxide is known as white arsenic. The chemical formula is As_2O_3 [also As_4O_6]; the molecular weight is 197.8, and the density is 3.7. Arsenic trioxide exists as an amorphous white powder or vitreous solid with a boiling point of 465°C. It sublimes at 193°C, and its solubility in water is 20.6 g/liter (Oak Ridge 1976).

(c) Sodium Arsenite

Sodium arsenite is an inorganic arsenical herbicide and insecticide (Meister 1977). The chemical formula is $NaAsO_2$. Its molecular weight is 129.9, and its density is 1.9. It exists as a grey-white powder and is very soluble in water (Oak Ridge 1976). Sodium arsenite is the reaction product of arsenic trioxide plus sodium hydroxide.

(d) Copper Acetoarsenite (Paris Green)

Paris green is the common name for copper acetoarsenite, which is formulated from arsenic trioxide (EPA 1976b). The chemical formula is $Cu(C_2H_3O_2)\cdot 3Cu(AsO_2)_2$, and the molecular weight is 586.2. The compound exists as an emerald green powder. It is insoluble in cold water and alcohol, and soluble in acid and NH_4OH (Weast 1977). Although copper acetoarsenite contains the salt of an organic acid, it behaves chemically as an inorganic arsenical (Letter 1975).

B. Formulation and Class

Lead arsenate is an insecticide and is available in dusts, wettable powders, fertilizer mixtures, and baits. Calcium arsenate is an insecticide and herbicide; it is available in dusts, wettable powders, baits, high water suspensions, and granules. Sodium arsenite

is a herbicide and insecticide; it is available in aqueous solutions at strengths of 4, 6, 8, and 9 1/2 pounds/gal. Paris green is an insecticide and is available in 5% granules. Arsenic acid is a cotton desiccant and herbicide, available as a 75% water miscible solution. Ammonium arsenite is a wood preservative and is available as a 7.7% pressurized formulation with other ingredients. (Pressurized formulations are manufactured for use in pressurized wood-treatment systems.) Arsenic trioxide is used as a rodenticide and is available as a bait formulation. Arsenic pentoxide and arsenic trioxide are used as wood preservatives and antifouling paints and are available as 1.5 and 37.0% pressurized formulations with other ingredients. Sodium pyroarsenate is a wood preservative and is available as a 6.2% pressurized formulation with other ingredients. Sodium arsenate is an insecticide and wood preservative and is available as a 43% dust, a 2% solution, and 14 to 43.5% pressurized formulations with other ingredients, and 0.7 to 3% baits (Meister 1977; EPA 1975).

C. Registered Uses and Production

Several inorganic arsenicals have long been used as pesticides. Copper acetoarsenite was used against the potato beetle in the Rocky Mountain region as early as 1865. Lead arsenate was introduced as an insecticide against the gypsy moth in Massachusetts in 1892. Sodium arsenite was used both as an insecticide and as a weed killer (HEW 1969).

Table 1 shows the number of companies holding Federal registrations for the various inorganic arsenicals or who have state registrations for such pesticides, and filed timely applications for federal registration pursuant to 40 CFR 162.17.[1/]

Table 1.

Registration	Product	Companies	Products
Federal	Standard Lead Arsenate	23	53
State	Standard Lead Arsenate	5	6
Federal	Basic Lead Arsenate	3	3
State	Basic Lead Arsenate	1	1
Federal	Copper Acetoarsenite	7	11
State	Copper Acetoarsenite	1	1
Federal	Calcium Arsenate	17	32
State	Calcium Arsenate	2	3
Federal	Sodium Arsenite	58	75
State	Sodium Arsenite	9	10
Federal	Ammonium Arsenite	2	2
Federal	Arsenic Trioxide	19	24
State	Arsenic Trioxide	3	5
Federal	Sodium Arsenate	15	20
State	Sodium Arsenate	2	2
Federal	Arsenic Acid	9	18
Federal	Arsenic Pentoxide	5	14
State	Arsenic Pentoxide	2	2
Federal	Sodium Pyroarsenate	1	1

1/ Prior to the enactment of the 1972 ammendments to FIFRA, federal registration was required only to ship or distribute a pesticide in interstate commerce. The 1972 ammendments to FIFRA extended the federal registration requirement to products in intrastate commerce. In implementing the 1972 ammendments, EPA permitted persons with valid state registrations to continue to sell and distribute their products, provided that timely application for federal registration was filed, and that other requirements set out in 40 CFR 162.17 were satisfied.

A total of 283 inorganic arsenic products are registered under Federal and state regulations. A registrant who has registrations for more than one type of arsenic (or who holds both Federal and state registrations for one or more types of arsenic) would be listed more than once.

Approximately 69% of all arsenic and its inorganic compounds produced in the U.S. is used for insecticides and herbicides. Over half of this amount is used by the cotton production industry as herbicides and desiccants for the preparation of cotton prior to machine picking. Another 7% of the total production is used as wood preservatives (OSHA 1977).

Most domestic arsenic production is in the form of arsenic trioxide which is derived from collected flue dusts from copper smelting. Since 1959, the entire U.S. production of arsenic trioxide has been at the Tacoma, Washington plant of the American Smelting and Refining Company (EPA 1976b). Arsenic trioxide is used to manufacture approximately 97% of other arsenic end-products (OSHA 1977). Since there is a single manufacturer for this material, recent production figures cannot be released. Section 7(c) of FIFRA requires manufacturers and formulators to submit to the U.S. Environmental Protection Agency (EPA) information on the production, sales, and distribution of

their pesticide products. This information is confidential and may be released only in accordance with the procedures outlined in Section 7(d) and 10 of FIFRA. A confidential memorandum summarizing this information has been sent to the Deputy Assistant Administrator for Pesticide Programs (Memo 1978a). Production figures are available, however, through 1968. For the ten-year period 1958 through 1968, production of arsenic trioxide averaged 4,745 metric tons/year.[2/] The lowest production figure was 2,340 metric tons/year in 1959, and the highest was 7,000 metric tons/year in 1965 (EPA 1976b).

From 1965 through 1972, the average consumption of lead arsenate as an insecticide on crops and for other uses was 3,500 metric tons/year, or 1,100 metric tons/year in equivalent arsenic trioxide; for calcium arsenate, the figures were 900 and 450 metric tons/year, respectively; and for copper acetoarsenite, they were 7,300 and 4,000 metric tons/year, respectively (EPA 1976b).

Use of arsenic acid as a desiccant on cotton has increased steadily since the late 1960s, from 965 metric tons/year in 1968 to 4,400 metric tons/year in 1974 (EPA 1976b).

2/ A metric ton equals 1,000 kilograms or 2,204.62 pounds.

The "National Study of Agricultural, Governmental and Industrial Uses of Pesticides" (Memo 1977c), conducted by EPA's Human Effects Monitoring Branch, provided data on the patterns of use of the following inorganic arsenicals for 1974: for calcium arsenate, 1,840 pounds active ingredient (AI) were used in agriculture on fruit and nuts, 446 pounds AI in government (use by Federal, state, and local governments), and 33 pounds AI in industry (use by pest control operators, utility companies, etc.); for copper acetoarsenite, 18,998 pounds AI were used in government, and 50 pounds AI in industry; for lead arsenate, 53,627 pounds AI were used in industry, 2,106 pounds AI in government, and a total of 333,788 pounds AI in agriculture (333,329 pounds on fruit and nuts, and 459 pounds on ornamentals and miscellaneous); for sodium arsenite, 20,287 pounds AI were used in government, 237,820 pounds AI in industry, and a total of 86,660 pounds AI in agriculture (57,344 pounds on fruit and nuts, and 29,316 pounds on ornamentals and miscellaneous).

The National Soils Monitoring Program (Memo 1977a), conducted by EPA's Ecological Monitoring Branch, has collected data on the application of inorganic arsenicals to various representative cropland sampling sites through 1974. The data indicated a limited use (<1%) of inorganic arsenicals (Table 2). Among the crops to which these inorganic arsenicals were applied were grapes, apples, oranges, peaches, potatoes, dewberries, and cotton.

Table 2.

Compound	Fiscal Year	Sites Sampled	% Sampled	Avg Total Application (pounds/acre)
Calcium Arsenate	1970	1/1,346	0.07	9.8
Sodium Arsenite	1969	4/1,684	0.24	5.25
	1974	1/1,165	0.1	16.5
Lead Arsenate	1969	1/1,684	0.06	3.8
	1970	1/1,346	0.07	6.4
	1972	3/1,473	0.2	7.07
	1973	1/1,402	0.1	4
	1974	1/1,165	0.1	7.68
Arsenic Pentoxide	1972	2/1,473	0.14	0.5

D. Tolerances

Copper acetoarsenite, ammonium arsenite, sodium pyroarsenate, arsenic pentoxide, and arsenic trioxide have no agricultural uses.

(1) Arsenic Acid

A tolerance for residues of orthoarsenic acid (arsenic acid) is listed in 40 CFR 180.180 as follows: 4 ppm (as combined AS_2O_3) in or on the raw agricultural commodity cottonseed.

(2) Calcium Arsenate

A tolerance for total residues of calcium arsenate is listed in 40 CFR 180.192 as follows: 3.5 parts per million (ppm) of combined As_2O_3 in or on asparagus, beans, blackberries, blueberries (huckleberries), boysenberries, broccoli, brussels sprouts, cabbage, car-

rots, cauliflower, celery, collards, corn, cucumbers, dewberries, eggplants, kale, kohlrabi, loganberries, melons, peppers, pumpkins, raspberries, rutabagas (with or without tops) or rutabaga tops, spinach, squash, strawberries, summer squash, tomatoes, turnips (with or without tops) or turnip greens, and youngberries.

(3) Lead Arsenate

Tolerances for total residues of lead arsenate are listed in 40 CFR 180.194 as follow: 7 ppm of combined lead in or on apples, apricots, asparagus, avocados, blackberries, blueberries (huckleberries), boysenberries, celery, cherries, cranberries, currants, dewberries, eggplants, gooseberries, grapes, loganberries, mangoes, nectarines, peaches, pears, peppers, plums (fresh prunes), quinces, raspberries, strawberries, tomatoes, and youngberries; and 1 ppm of combined lead in or on citrus fruits.

(4) Sodium Arsenate

A tolerance for residues of sodium arsenate (combined As_2O_3) is listed in 40 CFR 180.196 as follows: 3.5 ppm in or on grapes.

(5) Sodium Arsenite

Tolerances for residues of sodium arsenite (expressed as As_2O_3) resulting from dermal application

to animals under the supervision of the U.S. Department of Agriculture (USDA) are listed in 40 CFR 180.335 as follow: 2.7 ppm in kidney and liver of cattle and horses; and 0.7 ppm in the meat, fat, and meat byproducts (except kidney and liver) of cattle and horses.

USDA will issue a certificate to the owner of the animals showing the composition of the pesticide formulation and dates of treatment, and also specifying a minimum preslaughter interval of 14 days. In addition, 40 CFR 180.319 lists an interim tolerance for sodium arsenite of 0.05 ppm on grapes.

E. Fate in the Biological Environment

(1) Absorption

(a) Microorganisms

Microorganisms take up arsenates and arsenites via the phosphate transport system. Both arsenate and phosphate have an affinity for the transport system of yeast. Rothstein (1963) showed arsenate was taken up rapidly by bakers' yeast cells, but uptake then decreased and stopped within 40 minutes. Although arsenate and phosphate competed for the same transport system, phosphate was taken up twice as fast. Button and Dunker (1971) found that marine yeast accumulated

arsenate and phosphate through the same active transport system. Arsenate inhibited phosphate transport, and phosphate competitively reduced arsenate uptake.

Arsenic transport into bacterial cells (Escherichia coli) also involves the phosphate transport system. Bennett and Malamy (1970) found that a wild type of E. coli took up labeled arsenate in the absence of inorganic phosphate. If phosphate was then added, there was a rapid efflux of previously accumulated arsenate.

(b) Plants

Plants can absorb arsenical compounds from soil, water, and air through stomates, the cuticle (slow action), and cell membranes of roots, shoots, and coleoptiles. Exposure of plants to arsenic is from polluted air, pesticide-contaminated soil and water, and from naturally occurring deposits. Arsenic uptake is influenced by factors such as plant species, arsenical form, soil type, organic matter content, and ions present in soil (P, Ca, Al, Fe, Se, S). [See also Section I.E.(4)].

Sachs and Michael (1971) studied absorption of inorganic arsenic (sodium arsenite, sodium arsenate) and of organic arsenic (cacodylic acid, monosodium methane arsonate) by bean roots (Phaseolus vulgaris). When foliarly applied,

organic forms were translocated through the plant, while the inorganics were not. Both inorganic forms were more rapidly absorbed by bean roots than were the organics.

Soils have widely differing characteristics such as pH, oxide content, organic matter, and texture that affect the level of water-soluble arsenic in the soil (Walsh and Keeney 1975) [see also Section I.F.(1)(a)]. Woolson et al. (1971b) reported that the chemical form and solubility of the soil arsenic have more impact on plant growth than the total arsenic content of the soil. Translocation of arsenic is more extensive in warmer temperatures for most plant species.

The uptake of arsenic by plants (Table 3) is influenced by the soil elements and the plant species (Oak Ridge 1976). There is also competition between arsenic and phosphorous [see Section I.F.(1)(a)]. Rumburg et al. (1960) found that increasing the concentration of phosphorous in a nutrient solution decreased the amount of arsenate taken up by Clinton oats (Avena sativa). Jacobs and Keeney (1970) reported that phosphorus levels had little effect on uptake of arsenic by corn (Zea mays) grown in Waupun silt loam (80 ppm arsenic).

Table 3. Effects of Other Elements on Uptake of Arsenic by Plants

Plant	Other element	Effect of other ion on arsenic concentration	Reference
Clinton oats (*Avena sativa*)	Phosphorus	Decrease	Rumburg et al. (1960)
Corn (*Zea mays*)	Phosphorus	Increase in sand, little effect in silt loam	Jacobs and Keeney (1970)
Tobacco (Hicks variety)	Phosphorus	Increase	Small and McCants (1962)
Corn (*Zea mays*)	Calcium	Decrease	Woolson (1972)
Barley	Calcium	Little or no effect	Vandecaveye et al. (1936)
Plants (in general)	Aluminum	Decrease	Walsh and Keeney (1975)
Barley	Iron	Decrease	Vandecaveye et al. (1936)
Potatoes	Iron	Decrease	Steevens et al. (1972b)
Tobacco (Hicks variety)	Iron	Decrease	Small and McCants (1962)
Grasses, sunflower	Selenium	No correlation	Olson et al. (1940)
Rice	Sulfur	Decrease	Epps and Sturgis (1939)

(c) Animals

Insects, aquatic organisms, birds, and mammals generally take in arsenic by ingestion.

The manner of arsenic uptake by marine organisms is unknown (Penrose 1974). Fish feeding on arsenic-containing organisms probably obtain some arsenic by ingestion. Arsenic may be absorbed by crustaceans and by fish through the gills, as are other metals in the aquatic environment. Inorganic arsenic may be taken in with food and metabolized to water-soluble and lipid-soluble organoarsenical compounds (Schuth et al. 1974). Inorganic arsenic in water may be directly absorbed by fish.

Arsenic has been found in fish and aquatic invertebrates in both fresh and salt water [see Section I.E.(4)]. Aquatic organisms bioaccumulate arsenic but do not biomagnify it (Woolson 1975). They apparently are able to eliminate arsenic at approximately the same rate as it is ingested. In some cases, however, arsenic is found at higher concentrations in organisms than in the surrounding water. Gilderhus (1966) exposed bluegills to various concentrations of sodium arsenite. Arsenic residues were found in all tissues analyzed. Arsenic levels in fish increased during the exposure period and were higher in fish than in the water at the end of exposure.

Arsenic uptake by wild birds is primarily through ingestion of feed contaminated with residues of arsenical pesticides (Oak Ridge 1976).

Almost all arsenic uptake by mammals is through ingestion. Wildlife can take in arsenic by feeding in areas that have been contaminated with arsenical herbicides. Arsenic can also be absorbed through skin abrasions in sheep, cattle, and horses (Case 1974). Studies in mammals indicate that absorption of inorganic arsenic through the gastrointestinal tract can result in alteration of the chemical form (i.e., by methylation) before it reaches the general circulatory system and other organs.

(d) Humans

Arsenic can enter the body by ingestion, inhalation, and absorption through the skin. Several factors affect absorption, such as water solubility, lipid-solubility, type of arsenical, and area of absorption. Skin absorption is also dependent on the lipid-solubility of the compound. Lipid-insoluble arsenic salts are capable of combining with fatty acids in the skin to form lipid-soluble metal oleates which the skin is capable of absorbing (Rothman 1954). Oehme (1972) reported that inorganic arsenic is absorbed significantly through intact skin. Trivalent arsenicals are generally absorbed through the skin more readily than the pentavalent forms. Pentavalent inorganic arsenicals are better absorbed than trivalent forms in the digestive tract, probably because they react less with the intestinal contents and mucosa (Harvey 1975).

(2) Distribution

(a) Plants

Plant roots usually have the highest content of arsenic; vegetative growth has an intermediate level; and edible seeds of fruits contain the lowest levels (Walsh and Keeney 1975).

Machlis (1941) grew Sudan grass (*Sorghum vulgare, var. sudanense*) and bush bean (*Phaseolus vulgaris var. humilis*) in the greenhouse for varying lengths of time in nutrient solutions containing various concentrations of sodium arsenite. Leaves contained the highest arsenic concentrations, stem tissues contained an intermediate amount, and reproductive structures contained the least amount of arsenic. Concentrations many times greater than those of the leaves or nodes were observed in Sudan grass roots after they were placed in arsenic-containing nutrient solutions for one week (1 to 18 ppm arsenic in solution resulted in 338 to 1,461 ppm arsenic in roots). Sudan grass was more arsenic-resistant than the sensitive bean species.

Watanabe et al. (1971) reported that low levels (<0.10 ppm) of arsenic were detected in fruit from eggplant, grown in soil treated with 20 ml of arsenious acid (equivalent to 20 mg of arsenic per plant). Roots and leaves showed the highest arsenic concentrations (1.35 and 0.85 ppm, respectively) when 12.0 ppm arsenic was found in the upper layer of the soil.

Geisman et al. (1969) determined the concentration of arsenic in tomato plants grown under greenhouse conditions in soils that had been treated for at least two years with a sodium arsenite solution. Plants were grown on treated and drift portions of the plot and untreated controls were grown in a separate area. Table 4 shows that the highest arsenic concentrations were found in the roots and the lowest concentrations were found in the fruit.

Table 4. Average Arsenic Concentrations Found in Treated and Untreated Soil and Plant Samples (dry weight basis)

	Average Arsenic Concentration (ppm)[a/]			
Treatment	Soil	Roots	Stems and Leaves	Fruit
Untreated	<0.2	<0.2	<0.2	<0.2
Drift	331.0	400.0	187.0	<0.2
Treated	654.0	1707.0	334.0	1.4

a/ Data from Geisman et al. (1969).

Experiments with the lowbush blueberry (Vaccinium angustifolium) grown in commercial and virgin soils revealed a correlation between soil arsenic and arsenic in plant tissue (Anastasia and Kender 1973). Arsenic trioxide solutions of various concentrations were used to irrigate the soil. Analysis of arsenic content of leaves, stems, and roots indicted that roots absorb and translocate arsenic into the aerial organs (see Table 5). The greatest arsenic concentration was found in roots; stem concentration was slightly higher than leaf concentration. Tissue arsenic concentration increased as soil arsenic increased.

Table 5. Arsenic Accumulation in Leaves, Stems, and Roots of Lowbush Blueberry Plants Grown at Five Arsenic Levels in the Greenhouse for 17 Weeks[a/]

	Arsenic content (ppm)		
Total soil arsenic (ppm)	Leaves	Stems	Roots
7.7 (control)	0.78	0.27	2.40
17.1	3.55	3.95	50.02
43.8	6.74	7.58	93.72
69.5	8.14	11.64	121.28
84.5	14.97	13.33	164.22
LSD (0.05)[b/]	5.05	6.03	43.53

a/ Mean of three clones; data from Anastasia and Kender (1973).
b/ Test for significance of mean differences.

(b) Humans and Animals

According to Webb (1966), four major factors influence distribution of arsenic in animals: type of arsenical, animal species, route of administration, and time after administration.

With the exception of the rat, inorganic arsenic injected into mammals tends to concentrate in the solid tissues more than in the blood. Generally, the highest concentrations are in the liver, kidney, spleen, and lung. Trivalent arsenic will bind to sulfhydryl groups in animal tissue and slowly be released, while pentavalent forms are rapidly eliminated via the feces and urine. High concentrations of arsenic are found in hair and nails because it reacts with the sulfhydryl groups in the keratin (Harvey 1975).

Arsenic is a normal environmental contaminant and is always present in human tissues (Rentoul and Smith 1973). The total arsenic content of a normal adult body is estimated to be 14 to 21 mg (Harvey 1975).

In a study by Mealey et al. (1959), eleven patients dying of intracranial disease were given radioactively labeled trivalent arsenic intravenously. In a post-mortem examination, organs and tissues were analyzed for activity. The liver, kidneys, and spleen were the primary sites of arsenic accumulation.

In guinea pigs, rabbits, apes, and humans, radioactively labeled potassium arsenite was injected subcutaneously and was distributed primarily in skeletal muscles (Hunter et al. 1942).

Ducoff et al. (1948) studied the distribution of arsenic residues in various species of mammals, including humans, with radioactively labeled sodium arsenite (^{74}As). Eight Sprague-Dawley male rats were injected intravenously with 47 microcuries (uCi) each and were sacrificed in pairs at 6, 24, 48, and 96 hours. The authors noted the high concentration of arsenic in the blood, fairly high arsenic content of lung and spleen, the large individual variation, and the lack of any great tendency for a decline in the arsenic content of most tissues. The distribution of arsenic residues in four rabbits showed that concentrations of arsenic in blood at any time interval were never as great as in most solid tissues, that all tissues showed a distinct reduction in arsenic content over time, and that liver, kidney, and lungs contained the highest concentrations of arsenic.

The same authors also studied arsenic distribution in mice and humans. In a study on mice, 19 males of the A strain, 11 bearing lymphomas that had been transplanted three weeks previously, were injected intraperitoneally with 0.8 uCi radio-labeled sodium arsenite each. Arsenic concentration was determined in tissue samples of kidney, liver, lung, spleen, muscle, and tumor (when these were present). The ratio of arsenic concentration in kidney, liver, and

spleen of healthy inbred mice was found to be fairly constant for a given time after administration. Using this ratio as a criterion, it was found that arsenic distribution in tissues was altered unpredictably by the presence of transplanted tumors.

In the residue study on humans, a moribund 65-year-old female with carcinoma of the parotid (salivary gland) was given 500 microcuries (uCi) of ^{76}As (equivalent to 4 mg arsenic) 20 hours before death. The tissue distribution (in uCi/g) at time of death was as follows: liver, 46.4; kidney, 29.5; spleen, 16.1; parotid tumor, 15.6; heart, 14.6; heart, 14.6; jejunum, 14.3; vertebral marrow, 14.2; mesenteric lymph node, 12.8; stomach, 11.7; pancreas, 11.6; muscle (quadriceps), [illegible]4; ileum, 11.1; lung, 10.8; femoral marrow, 10.8; adrenal, 8.6; ovary, 8.3; thyroid, 7.6; skin, 6.7; brain, 2.5; and femoral cortical bone, 2.4.

In livers of fish from the Great Lakes, Lucas et al. (1970) found concentrations of arsenic ranging from 5.6 to 80 ppb. The arsenic was primarily in the fat fraction of the liver and other organs. Fish generally contain lower arsenic levels than other aquatic organisms (Lunde 1970).

(3) Excretion and Degradation in Animals

Webb (1966) has noted that arsenicals are excreted at different rates, depending on the valence state. The pentavalent arsenicals are usually excreted rapidly by the

kidney since they do not bind readily to tissues, whereas the trivalent arsenicals become rapidly bound and are excreted only as fast as they are released.

Mealey et al. (1959) suggested that arsenite administered intravenously into humans is excreted in three phases. More than 99% of a radio-labeled dose of sodium arsenite was excreted within 15 hours after administration. Labeled arsenic was excreted at a low, constant rate over the next 155 hours, and the remainder was removed at an even lower rate. Chemical tests of the urine indicate that the labeled arsenite is recovered as a mixture of arsenite and arsenate, the latter predominating.

Winkler (1962) showed that rats fed either sodium arsenite or sodium arsenate excreted primarily pentavalent arsenic, indicating *in vivo* oxidation of arsenite.

Harvey (1975) states that trivalent arsenic is slowly excreted in the urine and that this is the basis for its cumulative toxic action. Arsenate forms are rapidly excreted in humans and therefore little arsenic accumulates.

Coulson et al. (1935) studied the excretion of shrimp-arsenic (an organo-arsenical found in shrimp) in comparison to that of inorganic arsenic trioxide

(trivalent arsenical) in rats and humans. The "normal" level of arsenic excretion was determined for rats. Two groups of rats given a stock (no arsenic) diet excreted an average of 0.0059 and 0.0065 mg arsenic, respectively, in the urine (80%) and feces (20%). Rats in the first group were then fed a diet containing shrimp-arsenic for one day. Within four days, 74.6% of the arsenic had been recovered, and arsenic excretion fell to normal levels. The second group, however, which consumed a diet containing arsenic trioxide, eliminated only 19.1% of the ingested dose before arsenic excretion fell to normal levels; 80% was retained in the body. The experiment was repeated one week later with the first group of rats receiving the inorganic arsenic and the second receiving the organic shrimp-arsenic; the results were the same.

The same authors conducted a similar experiment on two humans. When the two subjects were given shrimp-arsenic in their diet, the rate of elimination was about the same as in the rat. When inorganic arsenic (As_2O_3) was added to the diet, it was excreted more slowly than the shrimp arsenic had been but was eliminated more completely than in rats.

Peoples (1964) studied the rate of urinary excretion of arsenic acid, a pentavalent arsenical, in cattle. Two animals received daily doses of 11.6 mg arsenic acid in the feed supplement for seven weeks;

two received 58.2 mg, and two received 291.0 mg. After seven weeks, the two low-dose animals had excreted 76 and 86% of the total arsenic ingested; the two mid-dose animals had excreted 79 and 58%; and the two high-dose animals had excreted 54 and 98%. The author suggested that the high levels of excreted arsenic indicated there is little arsenic storage in cattle tissue. The author indicated that preliminary studies showed that the tissue-bound arsenic was entirely pentavalent with no evidence of reduction to the trivalent form.

Lakso and Peoples (1975) fed sodium arsenate and sodium arsenite to cows and dogs for five consecutive days. Regardless of the arsenic form ingested, both animals excreted approximately equal amounts of methylated and inorganic arsenic. Crecelius (1977b) observed similar results when studying changes in the chemical speciation of arsenic following ingestion by man (see Section I.J).

Ginsburg (1965) reported that arsenate, given intravenously to dogs, was reabsorbed by the proximal renal tubule and reexcreted as arsenite (see Section I.J).

Ducoff et al. (1948) studied the excretion of radio-labeled sodium arsenite (a trivalent arsenical) in rats, rabbits, and humans. Five male Sprague-Dawley rats were each injected with 47 microcuries (uCi) of radio-labeled sodium arsenite (^{74}As); four rabbits were each injected with 235 uCi, and 2 human subjects were injected with 3.0 and 2.7 millicuries, respectively. The results showed

that, during comparable time intervals, arsenic excretion took place more slowly in the rats (<10% during the first 48 hours) than in rabbits (about 70%) or humans (about 30 to 45%). The authors also noted that the arsenic content of rats rapidly reached equilibrium. For all species, less than 10% of the excreted arsenic was found in the feces.

Fairhall and Neal (1938) studied the excretion of lead arsenate, a pentavalent arsenical, in two human subjects. After a preliminary period of three days on a controlled diet, both subjects received 10 mg of lead arsenate daily for ten days. Arsenic residues in urine and feces were measured for 23 days starting with the first day of exposure. The results showed that the arsenic was eliminated only through the kidneys. (Total arsenic residues in feces were only a few hundredths of a milligram.) About 96.4% of the arsenic was excreted in urine in the first subject, and about 77.5% in the second. The authors interpreted the immediate excretion of most of the ingested arsenic as evidence that lead arsenate dissociates in the gastrointestinal tract, even though its solubility in water is low.

Webster (1941) studied the excretion of lead arsenate in nine adult male orchardists who customarily ate unwashed apples treated with lead arsenate. During the 10-to-12-day experimental period, the subjects ate their usual number of treated apples (average, three apples) from separately provided lots. Analyses of samples of fruit eaten by the men showed a potential arsenic intake of 1 to 26 mg of lead

and 0.34 to 6.8 mg of arsenic per person per day. A portion of each day's urine and the total daily feces were analyzed for arsenic residues. The average arsenic residues for all nine persons over the experimental period was 0.019 mg in urine and 2.86 mg in feces. The total fecal arsenic was about 15% greater than the total urinary arsenic. The author compared this result with that obtained by Fairhall and Neal (1938) and suggested that the different results were caused either by differences between the chemical and physical properties of weathered spray residue and pure lead arsenate, or by differences in excretion of arsenic by persons having chronic exposure and those having acute exposure.

(4) Bioaccumulation and Biomagnification

The terms bioaccumulation and biomagnification are not treated consistently in scientific literature and are sometimes used interchangeably. For purposes of this document, however, bioaccumulation means the accumulation or concentration of pesticide residues in individual organisms or in individual species. Biomagnification, on the other hand, means the transference of pesticide residues from lower to higher organisms in the food chain, resulting in greater (magnified) concentrations of pesticide residues in higher organisms than were present in the lower forms.

Arsenic does not appear to biomagnify through the food chain (Oak Ridge 1976).

Arsenic does not continuously accumulate in mammalian tissues because it apparently reaches dynamic equilibrium

between intake and excretion (Frost 1967). Variations in the excretion rates of the different arsenicals by mammals are believed to be the basis for the varying toxicities (Frost 1967). The average human body burden of arsenic in normal adults is 14 to 21 mg (Harvey 1975); this arsenic is stored primarily in the liver, kidney, wall of the gastrointestinal tract, spleen, and lung, while smaller amounts are found in the muscle and nervous tissue. High levels of arsenic are also found in human hair and nails due to the high sulfhydryl content of keratin.

Since arsenic occurs naturally in aquatic systems, many aquatic organisms tend to bioaccumulate it. Due to the higher concentration of arsenic in salt water, marine organisms (plant and animal) tend to accumulate arsenic to a greater extent than freshwater forms (Woolson 1975). The highest rates of arsenic accumulation are found in aquatic plants (Woolson 1975). The lower aquatic organisms usually have the highest arsenic residues. Sohacki (1968) found plankton to be an effective accumulator of arsenic. Schuth et al. (1974) showed that there was greater arsenic accumulation by aquatic organisms such as algae and duckweed (lower level of food chain) than in fish and crayfish (upper level of food chain). In a review of the literature, Schroeder and Balassa (1966) reported that levels of arsenic are much higher in marine plants and animals than in terrestrial forms.

Ullmann et al. (1961) studied arsenic bioaccumulation by fish in Findley and Chautauqua Lakes in New York, which

were treated annually since 1956 with sodium arsenite for weed control. Detectable quantities of arsenic were found in the fillets (including skin) of all fish from Findley Lake, ranging from 0.27 to 0.47 ug/g. Seven of eight fish contained arsenic in the viscera (including bone and scales), ranging from 0.10 to 0.78 ug/g. No significant differences occurred between fish taken before or after spraying in either of the treated lakes. The fish from Chautauqua Lake contained less arsenic than those from Findley. Nine of 20 fish contained arsenic in the fillets ranging from 0.10 to 0.28 ug/g. Seven contained arsenic in the viscera ranging from 0.10 to 0.29 ug/g. These values were only slightly higher than those obtained in the ten control fish from untreated (control) Cassadaga Lake. Six of these contained from 0.10 to 0.12 ug/g in the viscera, and five contained from 0.10 to 0.14 ug/g in the fillets.

Terrestrial plants can bioaccumulate arsenic [see Section I.E.(2)(a)]. Since most plants are sensitive to arsenic, there is a reduction in growth before a high level of arsenic can occur (Walsh and Keeney 1975). [See also Sections I.E.(2)(a) and (6)].

Plants growing near a copper smelter were found to contain increased arsenic levels as a result of soil contamination with arsenic (Crecelius et al. 1974). Porter and Peterson (1975) measured the arsenic content of plants grown in contaminated soils (i.e., mine tips, and areas of smelter

waste). The foliage of several species contained 460 to 6,640 ppm, while plants in areas away from the smelter contained 0.28 to 0.33 ppm of arsenic.

(5) Biotransformation

In soil, sediment, and water, transformation is usually mediated by microorganisms. Various fungi and bacteria, under aerobic and anaerobic conditions, can metabolize arsenate and arsenite to volatile arsenicals, usually to di- or trimethyl arsine (Braman 1975; Walsh and Keeney 1975). The trivalent form of arsenic does not persist for long periods in well-aerated soils with significant biological activity (Walsh and Keeney 1975).

Limnetic and marine unicellular algae were able to synthesize fat- and water-soluble arseno-organic compounds from inorganic arsenic ions added to growth media (Lunde 1973b). A greater quantity of lipid-soluble organic compounds were synthesized in cultures with arsenate compared to those with arsenite.

Lunde (1969; 1972; 1973a; and 1973b) has demonstrated that arsenic is present in algae, fish, benthic organisms, and phyto- and zooplankton as water-soluble and lipid-soluble arseno-organic compounds. Studies indicate that arsenate is not a major form of arsenic in aquatic organisms (Woolson 1975).

Several studies of arsenic transformation in humans and animals have been done (see Sections I.E.(3) and I.J). Since the valence state of arsenic largely determines its toxicity, knowledge of the conversion *in vivo* is important. Most authors generally agree that trivalent arsenic is oxidized in tissues and excreted (at least in urine) in a pentavalent form; the reverse transformation, reduction of pentavalent arsenic, is not the favored reaction (see Section I.J).

(6) Other Biological Aspects

(a) Beneficial Effects in Mammals

Arsenic in small amounts may be essential and beneficial to cell metabolism. Attempts to confirm this have been hindered by the ubiquity of arsenic, which makes it difficult to obtain arsenic-free diets.

Muth et al. (1971) found that the addition of 1 ppm of sodium arsenate to selenium-deficient food reduced the incidence of myopathy in lambs. However, attempts have failed to show beneficial effects of arsenic in other selenium-deficiency diseases.

Nielsen et al. (1975) found symptoms of arsenic deficiency in rats fed a diet containing only 30 ppb of arsenic. Male rats had rough haircoats, a low rate of growth, splenomegaly, decreased hematocrit, and increased

osmotic fragility of red blood cells. Anke et al. (1976) found similar deficiencies in goats and laboratory pigs fed diets containing less than 50 ppb of arsenic. Compared to the control animals that received food supplemented with 350 ppb of arsenic, the experimental animals had impaired reproductive performance, decreased fetal weights, and increased neonatal mortality.

(b) Phytotoxicity

For many years, inorganic arsenicals have been used as pesticides, herbicides, and plant defoliants. As a result, plant growth has been reduced in some areas previously used for orchards and cotton fields (Walsh and Keeney 1975).

An example of severe phytotoxicity due to arsenic accumulation in the soil occurs in old orchard fields which are recycled for other crop uses (Bishop and Chisholm 1962; Vandecaveye et al. 1936). Some orchards have received over 1,000 kg/ha of arsenic while only 10 kg/ha were used as a defoliant in potato fields (Walsh and Keeney 1975).

Symptoms of arsenic phytotoxicity may vary with the plant variety, type of arsenical, method of application, and environmental conditions (Woolson et al. 1971b) [see also Section I.E.(1)(b) and I.F.(1)(a)]. Young tissue is generally more susceptible to injury than older tissue. Trivalent forms are more toxic than pentavalent forms and can bind with sulfhydryl groups, thus interfering with many enzymatic reactions. Arsenites usually produce rapid contact injury to membranes, which results in rapid water loss. Arsenates cause more subtle symptoms (chlorosis, but not loss of turgor), uncouple oxidative phosphorylation, and

stimulate respiration. They may react in the place of phosphates in many reactions (Ashton and Crafts 1973).

Reduced plant growth in corn (*Zea mays*) was associated with high concentrations of available arsenic in the soil (Woolson et al. 1971b). The authors indicated that the phytotoxicity of arsenic was influenced more by chemical form than by amount. Water-soluble arsenic was more toxic than water-insoluble arsenic. Reduced phytotoxicity occurred in soils containing arsenic and high levels of reactive aluminum versus soils containing arsenic and low levels of reactive aluminum.

Other studies have shown that arsenic can retard plant growth and transpiration (Kerr 1941; Morris and Swingle 1927; and Woolson 1973).

Table 6 gives the toxic levels of soluble arsenic for various crops.

Table 6. Toxic Levels of Soluble Arsenic to Various Crops and Vegetables

Plant	Toxic level Soluble As (ppm)	Reference
cowpeas	1	Albert and Arndt (1931)
barley	2	Vandecaveye (1943)
snap beans	2.5 a/	Jacobs et al. (1970)
peas	2.5	Jacobs et al. (1970)
	9 a/	Bishop and Chisholm (1962)
alfalfa	3.4-9.5	Vandecaveye et al. (1936)
soybeans	3-12	Deuel and Swoboda (1972)
rice	7	Epps and Sturgis (1939)
cotton	8-28	Deuel and Swoboda (1972)
beans	9	Bishop and Chisholm (1962)
corn	20 a/	Jacobs et al. (1970)
potatoes	37 a/	Jacobs et al. (1970)
green beans	10-50	Woolson (1973)
lima Beans	10-50 a/	Woolson (1973)
spinach	10-50 a/	Woolson (1973)
tomatoes	50 a/	Woolson (1973)
radish	40-100 a/	Woolson (1973)
lowbush blueberry	84.5	Anastasia and Kender (1973)
cabbage	100 a/	Woolson (1973)

a/ Level which produces 50 percent yield reduction.

(c) Beneficial Effects in Plants

Although arsenic is not an essential plant nutrient, relatively high arsenic concentrations in soil may have beneficial effects on plant growth (Walsh and Keeney 1975). Stewart and Smith (1922) found that a concentration of 25 ppm in soil enhanced the growth of peas, radishes, wheat, and potatoes. However, beans showed a steady decrease in growth as the arsenic content increased. MacPhee et al. (1960) reported increased turnip yields in soil with a total arsenic content of 126 ppm. The increase in yield was attributed to control of the turnip root maggot. There was a decrease in the yield of other crops such as peas and beans.

There have been beneficial effects on several crops in fields treated with high concentrations of calcium arsenate. Decreased yields for vetch, oats, and barley were first noted in soil with total arsenic concentrations of 94, 188, and 283 ppm, respectively [calcium arsenate applied at 500, 1,000, and 1,500 pounds/acre] (Cooper et al. 1931). When calcium arsenate was applied below these levels, the treated soil had a higher yield than the untreated soils. In another study, corn, sorghum, soybeans, and cotton showed yield increases from applications of 188 ppm [1,000 pounds/acre] (Cooper et al. 1932).

Woolson et al. (1971a) postulated that the stimulation of growth in plants by small amounts of arsenic may be similar to that of other pesticides (e.g., 2,4-D) at sublethal dose levels.

F. Fate in the Physical Environment

(1) Distribution

(a) Soil

Arsenic occurs as a natural constituent in almost all soils. The earth's crust has an estimated background arsenic concentration of 6 ppm [range of 0.1 to 40 ppm] (Bowen 1966). Although there are several sources of inorganic arsenic (i.e., natural weathering of arsenic-containing rock, smelters, volcanic debris, and pesticides), residues from pesticides are a major source of arsenic pollution (Woolson 1976). They are also the major source of arsenic emitted to the environment, but the use of these products is now declining for various reasons (Sullivan 1969). Thirty-two percent (32%) of the total emissions in the U.S. of arsenic are from pesticide use (Duncan et al. 1973).

Williams and Whetstone (1940) sampled soils which had not been contaminated with arsenical pesticides. All samples contained from 0.3 to 38 ppm of arsenic (30% contained less than 5 ppm; 50%, 5 to 10 ppm; and 20%, greater than 10 ppm). Jones and Hatch (1945) compared four plots of soil, arsenic-treated and untreated, after 20 to 25 years of pesticide spraying. The arsenic content was 20 to 30 times the original level. Woolson et al. (1971a) surveyed soils in the U.S. with a history of arsenic treatment. The overall average residue level was 165 ppm, while in control soils it was 13 ppm.

Walsh and Keeney (1975) summarized the arsenic levels for treated and untreated soils in parts of North America. Untreated soils had an arsenic range from undetectable to 80 ppm, while treated soils ranged from 1 to 2,553 ppm (see Table 7).

Table 7. Comparison of Arsenic Levels in Arsenic-treated and Uncontaminated Soils in North America

Sampling site	Total arsenic content (ppm) Uncontaminated soil	Treated soil[a/]	Crop
Colorada	1.3-2.3	13-69	Orchard
Flordia	8	18-28	Potato
Idaho	0-10	138-204	Orchard
Indiana	2-4	56-250	Orchard
Maine	.9	10-40	Blueberry
Maryland	19-41	21-238	Orchard
New Jersey	10	92-270	Orchard
New York	3-12	90-625	Orchard
North Carolina	4	1-5	Tobacco
Nova Scotia	0-7.9	10-124	Orchard
Ontario	1.1-8.6	10-121	Orchard
Oregon	2.9-14	17-439	Orchard
	3-32	4-103	Orchard
Washington	6-13	106-830	Orchard
	8-80	106-2553	Orchard
	4-13	48	Orchard
Wisconsin	2.2	26	Potato

a/ These are results from soils that had been repeatedly treated with an arsenic pesticide or defoliant. Soils treated experimentally are not included. Data from Walsh and Keeney (1975).

Greaves (1934) studied soils from 50 orchards and found that levels of arsenic varied from 26.4 to 1,353.3 kg/ha-m (7.2 to 367.2 pounds/acre-ft). Bishop and Chisholm (1962) compared surface soil from 25 orchards to soil from control (untreated) soils and found arsenic accumulation due to the use of pesticides. In Canada, Miles (1968) studied soil from four apple orchards. The arsenic level ranged from 10.2 to 107 ppm between the trees, and from 15.6 to 121 ppm under trees. Soil from untreated vegetable fields generally had under 10 ppm of arsenic.

Arsenic from smelter emissions can contaminate the surrounding soil. Crecelius et al. (1974) reported surface soil contamination of up to 380 ppm within a 16-mile distance from a smelter stack, with suspected contamination as far as 112 miles away. Ratsch (1974) reported arsenic

concentrations of 7.3 to 457 ppm within a 6-mile radius of a copper smelter.

Soil adsorption of arsenicals is dependent on soil pH, texture, iron and aluminum oxide content, phosphorous level, and the organic matter content (Woolson 1976). Arsenic that is adsorbed to soil or sediment is fixed as slightly soluble compounds (Woolson 1976). There is an equilibrium between the arsenic in solution and that fixed in the soil or sediment (Woolson 1976). Soluble arsenic is subject both to leaching, especially in sandy soil where there is little potential for forming adsorption complexes, and to removal by surface run-off to ground waters, lakes, and rivers.

Unlike heavy metals, there is decreased adsorption of arsenates in soils with high pH (Misra and Tiwari 1963). Depending on soil texture, soils adsorb arsenate in the following decreasing order: clay, clay loam, silt, loam, loam sand. Arsenic, like many heavy metals, is persistent in soils with a high concentration of hydrous oxides, especially those of iron and aluminum found in laterite, bauxite, and silicate soils. Arsenic is decreasingly reactive with Fe > Al > Ca > Mg, to form increasingly soluble salts (EPA 1976c). If levels of reactive Fe, Al, and exchangeable Ca are low, arsenic is more likely to leach (Woolson et al. 1971a). Because of chemical similarities, arsenate ions can compete with phosphate ions for adsorption to soil minerals. Fixed arsenate can be readily replaced in the presence of phosphate ions (Woolson 1972). Increasing calcium levels will decrease arsenate retention in soil.

Precipitation can affect the persistence of arsenic in soil. Over a period of years, arsenic will leach from

soil with adequate rainfall. With limited rainfall, however, arsenic can accumulate in soils where leaching occurs more slowly due to high iron and aluminum oxide content.

Arsenic in the soil can be removed naturally by volatilization (from biotransformation), leaching, wind-born dust, run-off, plant uptake, and crop removal.

(b) Water

Small quantities of arsenic occur in virtually all natural waters. Ground waters usually contain more arsenic than surface waters. Naturally occurring arsenic in sea water averages 0.003 ppm while rivers average about 0.0004 ppm (Bowen 1966). Elevated arsenic levels in water are usually the result of pollution. The average content of arsenic in fresh water (about 1.5 to 2 ug/liter) is below the recommended drinking water standards for the United States (Woolson 1975). Water near natural deposits of arsenic or areas of volcanic activity tend to have higher levels of arsenic.

Although there is disagreement among scientists as to the oxidation state of arsenic in sea water, it is agreed that there is an equilibrium between arsenate and arsenite forms (Woolson 1975). There are indications that, in the oxidizing layers of the ocean, arsenic is in the pentavalent state, while at lower depths it is reduced to the trivalent state (Woolson 1975). This equilibrium may also exist in stratified lakes.

The strong association of arsenic with clays high in iron and aluminum oxides is an important means of transferring arsenic to streams, lakes, and sediments [see Section I.F.(1)(a)]. Arsenic can enter natural waters by

run-off and leaching from arsenic-treated soils. The hydrous metal oxides in the sediments can adsorb the arsenic, removing it from solution, thereby preventing build-up of high concentrations (Woolson 1976). Sediments in polluted rivers have been found to contain up to 220 ppm of arsenic (Oak Ridge 1976).

Arsenic can be removed from solution by volatilization (as alkyl arsines), adsorption by clays and detritus, and coprecipitation with metal ions (Ferguson and Gavis 1972).

(c) Air

Arsenic in the atmosphere is primarily the result of human activities and, to a lesser extent, volcanic and bacterial action. There is generally low atmospheric arsenic except near local pollution sources such as metal smelters, cotton gins, and areas of pesticide application. The air of most U.S. cities contains a small amount of arsenic, while air in rural areas has a relatively low concentration of arsenic (Sullivan 1969).

Arsenic moves in air adsorbed to particulate matter, and it is returned to the soil by direct fallout or by precipitation (Woolson 1976). It has been hypothesized that volatile arsenicals released to the atmosphere are oxidized in the presence of light and returned to the soil via dry fall (as particulate matter) or in precipitation (Woolson and Kearney 1973).

(2) Degradation and Transformation

In nature, most arsenicals are converted to arsenate (pentavalent) which is the stable oxidation state in oxygenated environments. Arsenite (trivalent) is the dominant form in anaerobic conditions (i.e., flooded soils, submerged

sediment layers). Arsenate may be reduced to arsenite under conditions of low pH (Misra and Tiwari 1963). Arsenite will not persist for long periods in well-aerated soils with significant biological activity. Oxidation also occurs in alkaline soils or those containing ferric and aluminum oxides (Misra and Tiwari 1963).

In air, arsenic is transformed by abiotic oxidation (Lee et al. 1977). In the soil and water, transformation is usually mediated by organisms (Sandberg and Allen 1975). Trivalent forms (arsenite) can be oxidized to the pentavalent (arsenate) both abiotically and biotically. Pentavalent forms can be reduced anaerobically. Methylation occurrs anaerobically and aerobically by many microbial species (Cox 1975).

In sea water, there is an equilibrium between arsenate and arsenite with the pentavalent form predominating (Woolson 1975). In the aerobic (oxidizing) layers of the ocean, the reduced forms of arsenic will be oxidized to arsenate. At lower ocean depths where oxidation is not as great, chemical or microbial reduction may occur (Woolson 1975).

Both arsenates and arsenites can precipitate with ferric hydro-oxides in water (Woolson 1975). Ferric arsenates and arsenites can then accumulate in ocean sediments where solubilization as arsines, stabilization as sulfides, or reduction to arsenic metal can occur. Turbulence and convection can transport arsenates to lower oxygen-depleted depths where they may be reduced to arsenites or AsS_2 (Woolson 1975).

G. **Residues**

(1) **Soil**

Residual arsenic tends to be concentrated in the surface layers of the soil (Jones and Hatch 1945; Vandecaveye et al. 1936). With regular treatments of sodium arsenite, arsenic was reported to have accumulated to the extent that leaching equaled the addition of arsenite (Tammes and de Lint 1969).

EPA's National Soils Monitoring Program (Memo 1977a, 1977b) has limited data on noncropland (i.e., nonurban and nonagricultural) soil sampling for arsenic residues for fiscal year (FY) 1969 and 1972. In FY 1969, a total of 198 noncropland soil samples were analyzed from 11 states; 195 samples showed arsenic residues. In eight of the states, 100% of the sites showed arsenic residues, and in the other three 94.1, 94.7, and 97.3% of the sites showed arsenic residues. The lowest arithmetic mean for arsenic residues from any one state was 1.47 ppm, and the highest was 8.43 ppm. The lowest residue level in any one state was 0.33 ppm, and the highest was 39.07 ppm.

In FY 1972, a total of 254 noncropland soil samples were analyzed from 18 states and geographic regions; 242 samples showed arsenic residues. In 12 of the states, 100% of the sites showed arsenic residues, and in the other six 75.0 to 94.7% of the sites showed arsenic residues. The lowest arithmetic mean for arsenic residues from any one state was 1.68 ppm, and the highest was 16.66 ppm. The lowest residue level in any one state was 0.41 ppm, and the highest was 38.05 ppm.

As part of this program, soil samples were analyzed for elemental arsenic (As) in selected urban areas from 1971 through 1976, and in agricultural soil from FY 1969 through 1972. Analysis of urban samples is not yet complete for

cities sampled in 1976 and for several in 1975. For the 24 cities on which analysis has been completed, however, 20 showed arsenic residues in 100% of the samples analyzed; the other four had arsenic residues in 92.3 to 98.9% of the samples analyzed. The lowest arithmetic mean for arsenic residues from any one city was 1.84 ppm, and the highest was 25.28 ppm.[3/] Agricultural soil samples were taken from the National Soils Monitoring Program sites. Arsenic analyses were discontinued in FY 1973. Because arsenic is a naturally-occurring element in soils, arsenic was detected in about 99% of the samples, and the arithmetic mean remained fairly constant during the period of sampling.

Carey et al. (1976) studied 14 U.S. cities of various sizes for pesticide residues in soil during the summer and fall of 1970. Sample sites (231 m^2) were randomly selected in each city. Arsenic residues were found in 97% of the samples analyzed. Geometric mean values for arsenic ranged from 0.5658 ppm in Cheyenne, Wyo., to 8.5081 ppm in Philadelphia, Pa.

In 1970, Steevens et al. (1972a) studied arsenic residues in soil from Wisconsin potato fields in which sodium arsenite had been extensively used as a defoliant from 1958 to 1968. Composite soil samples of 10 randomly selected cases from the plow layer were taken from 18 potato fields in the three principal potato-growing areas of Wisconsin. The authors noted that the level of naturally occurring arsenic in soil ranged from 2 to 10 ppm. This

3/ The highest average arsenic level was in Tacoma, Washington, site of a copper smelter which, based on the high ambient arsenic levels observed, has been described as "one of the most important individual sources of arsenic with emissions of 310 tons/year" (EPA 1976b). These residues seem clearly to be of industrial, rather than agricultural, origin.

study showed arsenic soil levels of <10 ppm at seven sites and from 10.0 to 25.7 ppm at 11 sites. The authors concluded that past usage of sodium arsenite in these fields had not resulted in arsenic levels which would be detrimental to crops.

(2) Water

A report on drinking water and health by the National Academy of Sciences (NAS 1977a) noted that the maximum no-observed-effect level for arsenic in water is <100 ug/liter. The report called the current mandatory U.S. drinking water limit of 50 ug arsenic/liter "only a meager margin of safety," since intake from 2 liters/day of water containing 20 ug arsenic/liter is slightly greater than 10% of the median total intake of arsenic. The current World Health Organization and U.S.S.R. limits for arsenic in drinking water are 50 ug/liter.

(3) Air

Arsenic residues in air result from smelting of metals; burning of coal, vegetation treated with arsenicals, and agricultural wastes; ginning of cotton; and use of arsenical pesticides.

The use of arsenical pesticides constitutes a major source of air pollution. From 1937 to 1940, Neal et al. (1941) studied the amount of arsenic and lead in the air from the use of lead arsenate in orchards. The arsenic concentration was highest when pesticide containers were burned (16,670 ug/m^3), followed by mixing the pesticide (1,850 ug/m^3), picking the fruit (880 ug/m^3), spraying the pesticide (140 ug/m^3), and thinning the fruit (80 ug/m^3).

Arsenic in dusts and gases from cotton gins is another source of arsenic air pollution. The pesticides are used for weed control and for cotton desiccants. From 46 to 91 miles downwind of a cotton gin in Texas, arsenic concentrations in the air varied from 600 to 141,000 ng/m^3 (HEW 1967).

(4) Fish

Mackenthun (1960) studied the long-term effects of sodium arsenite used as an aquatic herbicide in Wisconsin. One lake with an area of 2,501 acres had received the equivalent of 87 pounds of As_2O_3 per acre, during the period 1950 to 1960, along the shoreline. Arsenic content in fish from this and an untreated lake was determined. One largemouth bass from the treated lake showed no arsenic residues. A largemouth bass, a black crappie, and a bullhead showed <0.05 ug/g As_2O_3 in flesh and 0.1 ug/g in skin and scales. One 7-inch bluegill had 0.064 ug/g in flesh and 0.27 ug/g in flesh and 0.127 ug/g in skin and scales. Fish from the untreated lake showed no arsenic residues.

Lucas et al. (1970) conducted a study on concentrations of trace elements, including arsenic, in fishes from three Great Lakes (Michigan, Superior, and Erie) during 1968 and 1969. Species used for whole-body analyses were alewives (Alosa pseudoharengus), spottail shiners (Notropis hudsonius), and trout-perch (Percopsis omiscomaycus). Since alewives were small, about 20 were combined for each sample; spottail shiners and trout-perch were analyzed individually.

Alewives from Lake Michigan contained 23 ppb arsenic (based on a single determination); spottail shiners from

Lake Michigan contained 3 ppb (based on a single determination); and trout-perch from Lake Michigan contained an average of 43 ± 12 ppb. Spottail shiners from Lake Erie contained 3.5 ± 3.0 ppb arsenic/g of tissue, and trout-perch from Lake Superior contained 7 ± 2 ppb. The authors noted that arsenic concentrations in trout-perch from Lake Michigan appeared to be significantly higher than in those from Lake Superior.

The authors also determined the arsenic concentration in livers of 10 species of fish. Lake herring (Coregonus artedii) from Lake Superior contained an average of 69 ± 30 ppb arsenic/g of tissue; lake whitefish (C. clupeaformis) from Lake Superior contained 6.4 ± 0.7 ppb; bloater (C. hoyi) from Lake Superior contained 63 ± 17 ppb; round whitefish (Prosopium cylindraceum) contained 5.6 ± 3.4 ppb; and lake trout (Salvelinus namaycush) contained 80 ± 10 ppb. Fish from Lake Erie which contained arsenic concentrations included goldfish (Carassius auratus), 0.3 ± 0.2 ppb; white bass (Roccus chrysops), 0.8 ± 0.4 ppb; and walleye (Stizosteidion v. vitreum), 0.8 ± 0.5 ppb.

Walsh et al. (1977) conducted a study of arsenic and heavy metal residues in fish from 1971 to 1973 from 100 monitoring stations throughout the 50 states and Puerto Rico. The detection limit for arsenic was 0.05 mg/kg. The authors noted that only selected samples were analyzed in 1973 and that these figures should be used cautiously as trend data. The results showed that arsenic was present